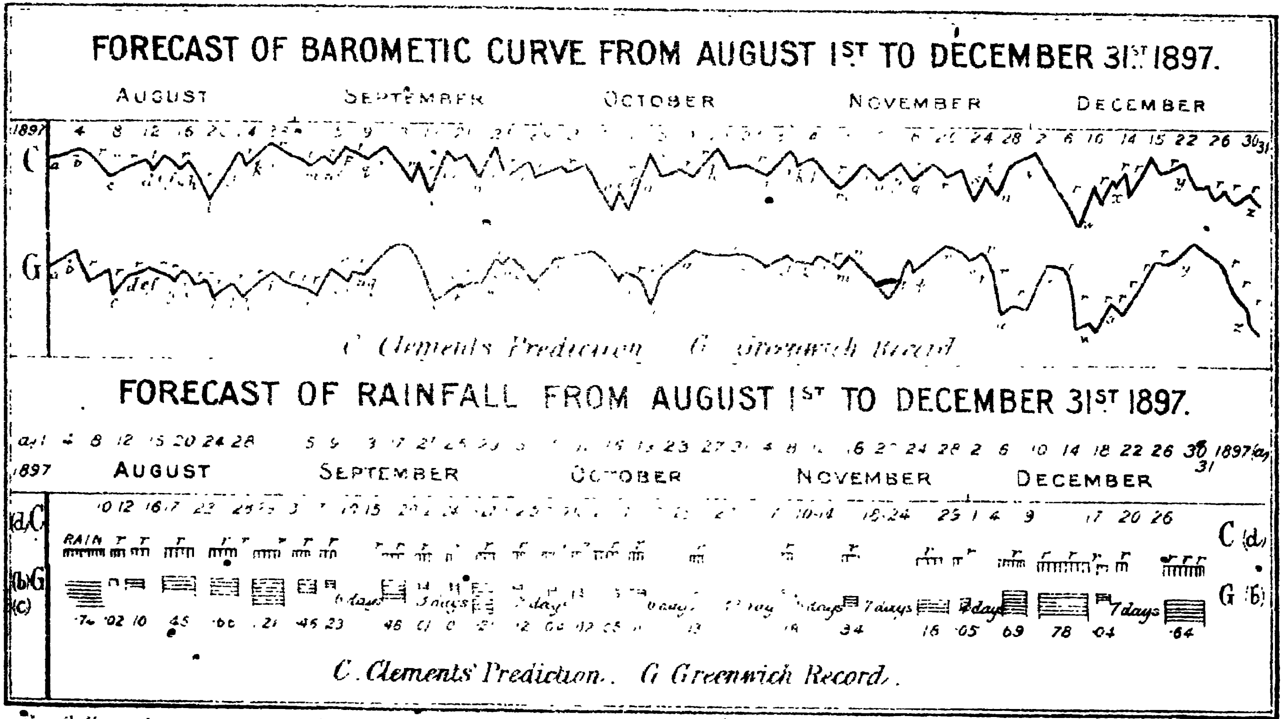
NATURAL LAW IN TERRESTRIAL PHENOMENA

THE FUTURE OF THE METEOROLOGIST

'The day of the medicine-man with his rain-making charms is past. The future belongs not to the magician, who attempts to interfere with the laws of nature, but to the man of science, who can state with something approaching to certainty how they will operate under given conditions. Of all those who contribute to the cause of human progress, and the transference of human activities from the sphere of the accidental to the sphere of the causal, none perhaps are concerned with weightier issues than the men who patiently and persistently day by day, and season by season, measure and compare, compare and measure, the rainfall of their little districts. We may forgive the meteorologist his uninteresting statistics when we reflect that in their trustworthiness and in their right interpretation may lie the future of an abundant food-supply and even industries yet undeveloped.'—A. J. HERBERTSON, Ph.D., Lecturer in Regional Geography in the University of Oxford, art. 'The Distribution of Rainfall,' *Harper's Magazine*, November 1902.



For full explanation of the letters on this Diagram see Chapter "The Weather Day by Day"

Natural Law in Terrestrial Phenomena

A STUDY

IN THE CAUSATION OF

EARTHQUAKES
VOLCANIC ERUPTIONS
WIND-STORMS
TEMPERATURE
RAINFALL

WITH

A RECORD OF EVIDENCE

BY

WILLIAM DIGBY, C.I.E

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'After all, the test of any prediction is its success or otherwise.'—W. H. M. Christie, *Astronomer Royal for England*

'Prediction must inevitably fail, unless we have lighted on the true cause of the phenomena : success is, therefore, a guarantee of the truth of the theory.'—Prof. G. H. Darwin

LONDON
WM. HUTCHINSON & CO
TRAFALGAR BUILDINGS CHARING CROSS
1902

To the solid ground
Of Nature, trusts the mind that builds for aye?
—Wordsworth

TO

The Astronomers Meteorologists and Geologists of the United Kingdom

WHOSE SINGULAR AND UNEQUALLED DEVOTION AND ZEAL

IN THE

STUDY OF NATURAL PHENOMENA

PRODUCE GREAT RESULTS AND WIN ADMIRATION FROM ALL WHO BECOME ACQUAINTED WITH THEIR PAINSTAKING, CONTINUOUS, AND OFTEN VOLUNTARY, OBSERVATIONS AND RECORDS WHICH CONSTITUTE

A MONUMENT OF UNWEARIED INDUSTRY

THE ATTEMPT (HEREIN RECORDED) TO GET BEHIND VARIOUS OUTWARD MANIFESTATIONS OF

TERRESTRIAL PHENOMENA

(AN ATTEMPT CONCEIVED AND CARRIED OUT IN A REVERENT AND SCIENTIFIC SPIRIT) AND THE

BODY OF EVIDENCE AND EXAMPLES

OF HITHERTO UNRECOGNISED CO-ORDINATION OF NATURAL FORCES IN THE CAUSATION OF PHENOMENA ARE

SUBMITTED FOR CONSIDERATION AND EXAMINATION AND RESPECTFULLY DEDICATED,

IN THE HOPE THAT IT MAY BE RECOGNISED AND AGREED THAT ONE MORE OF NATURE'S SECRETS HAS BEEN WRESTED FROM THE UNKNOWN

PREFACE

POSSIBLY this work might commend itself more readily to students of meteorology and to the public at large if its author were a recognised authority in meteorological science. He is, however, merely a humble student of natural phenomena. This matters less than it might have done from the fact that he is not putting forward discoveries of his own, but sets forth and discusses the discoveries of another. Certainly he has this qualification for the duty he has assumed that, for more than forty years, he has taken a deep interest in astronomy and meteorology, and has devoted such leisure as he could obtain to their study; that his position in Ceylon—1871 to February 1877—brought him into close contact with the meteorological conditions and needs of that island; and that, in India, his close connexion with famine relief in 1877–79, and his unintermitted studies from that period to the present time into the physical and economic causes of the famines in our Eastern Empire, betoken long and continuous interest in the subject. Especially, for a considerable time, the likelihood of cycles of rainfall among weather phenomena has been a feature in that interest.

During the years 1873 to 1876, the author had the privilege and opportunity of studying the Ceylon rain-cycle researches of the late Robert Boyd Tytler, of Aberdeen, then owner and manager of the great coffee and cocoa estates of Pallakellie and Dambetenne, near to Kandy, Central Province of Ceylon. Mr. Tytler's diligence had procured for his own study a great mass of information from which he deduced conclusions that, in Ceylon, pointed to alternate periods of maximum and minimum rainfall. These were freely produced and as freely discussed. It was, however, in 1878 and 1879 that the author obtained such experience as might indicate that he is not altogether unqualified to present to the public researches made by another, and his own studies in connexion therewith, as recorded herein. During nearly the whole of 1878 and until August, 1879, the author resided at the Government Observatory in Madras with Mr. Norman R. Pogson, C.I.E., the Imperial Astronomer for India. Mr. Pogson was not only astronomer for the whole of India but he was also meteorologist for the Madras Presidency, having within his sphere of operations a territory larger than Spain, especially interesting from its position as a peninsula dipping deeply into surrounding oceans, served on its western coast by the South-West monsoon, and on its eastern side by the North-East monsoon. The author's residence with Mr. Pogson coincided with the period when

the sun-spot theory as affecting rainfall was at the zenith of its popularity. As Mr. Pogson was one of the pioneers—at Oxford in 1858—in this region of research, had himself pressed his conclusions upon the Government of India, and, by what he had done, had made possible the later exhaustive, if inconclusive, investigations of Sir Norman Lockyer and Mr. W. J. S. Lockyer, Ph.D., it will not be thought strange that the various aspects of meteorology, as affected by the movements of certain of the heavenly bodies, should possess an interest for the present writer, or that he should have gathered some little knowledge of weather phenomena. How limited, alas! at its little best that knowledge is, he only too keenly feels! The author apologises for this intrusion of purely personal matters upon the reader, but, in view of the statements and conclusions which, in his opinion, justify the publication of this work, some such explanation seemed necessary.

Dropping the third person singular, may I further say that I was driven to the consideration of the important problem for which, to my mind, Mr. Hugh Clements has found a satisfactory solution, by my deep sense of the grievous needs of India arising out of the frequent famines which afflict that distressful country? It is true, as none assert more strongly than the present Administrators of India, that the famines are largely famines of money, not famines arising from an absolute lack of food, and, there-

fore, not attributable wholly to drought; the stores of grain have never yet, in times of direst need, been wholly depleted. Nevertheless a system of weather forecast which would enable the authorities to learn, for ten years ahead if they wished, what the extent and duration of rainfall and other meteorological conditions would be week by week, and, as experience grew, even day by day, in every part of the Empire, could not fail to be of almost inestimable value. This knowledge would impose a great responsibility upon the authorities for the provision of means to rightly use the opportunities provided by Nature, and must necessarily lead to the adoption by them of thorough and much-needed preventive measures.

To return from this digression to the main question. A desire to be of practical service to

Not, however, may it be assumed that, with normal rainfall every year or by the exercise of such precautions as the storage of the surplusage of water in good years and the conservation of what falls at inappropriate times, famine in India would cease. Economic causes are at work in that land which hinder the acquisition of wealth by Indians for employment within the borders of their own country; these causes play no unimportant part in the continuance of Indian famines. That, however, is a topic which may not be treated here. It is merely mentioned in passing lest it should be supposed that I, who, in other places and in other ways, have insisted, and am still insisting, that drought is not the sole, or even the most important, cause of Indian famines, am now prepared to assert, or agree with the assertion, that a sufficient supply of rain, or a thorough system of storage tanks or lakes, would fully meet the needs of Britain's Eastern Empire. They would do much, very much, but they would not do everything that is needed.

India in respect to the prevention of famine led me, on the suggestion being made, to associate myself with the London representative of several Indian journals in a consideration of certain forecasts of Indian weather which Mr. Clements had made. This consideration necessitated repeated interviews with Mr. Clements and a study of his twenty years' work in climatology. That study led me to examine more fully into Mr. Clements' methods, more particularly into his achievements, than I had intended. I say, his achievements, for, after all, be the antecedent objections to a theory what they may, that theory has a right to be judged by its submission of proof of the conclusions to which it points, exactly as the value of a tree, never mind what opinion may have been formed concerning it, is to be judged by the fruit it yields. Thus regarded, Mr. Clements seemed to me, in all that he furnished, to be dealing with the facts of Nature herself. What he did was done in a strictly scientific spirit. The predictions he published, long anterior to the periods to which they referred, were found by me to be fulfilled, in some instances, with an accuracy that was almost uncanny; in other instances the approximations to accuracy were greater than those which characterise accepted facts of science,—the prediction of tides, for example. I did not enter upon this inquiry with any bias in favour of Mr. Clements' views. They might be correct, but (so I reasoned) the chances

were that they were not. It is true I was not fully acquainted with the scientist's views. I had never met him. I only knew of him as any diligent reader of the London newspapers for the past ten years must know him, as a weather prophet with the courage of his convictions, and, if one might judge from what was said about him, as well as what he said himself, with not a few successes in prediction standing to his credit. With ninety-nine per cent. of that portion of humanity which concerns itself with the weather, I thought—I had never given the matter any special consideration—it was amongst the patent absurdities of a too credulous age of unscientific and undeveloped thought, to suppose that the moon, even when in association with the sun, had any part in controlling our weather or had aught to do with earthquakes and volcanic eruptions. As for the latter phenomena Mr. Clements was not slow to assert, *a propos* of the Martinique and St. Vincent outbursts, which occurred during our earlier interviews with him, that they were the direct result of the luni-solar influence, exerted on that particular part of the earth in which the Caribbean Sea is situate and at that particular time. We marvelled at his assertions and then investigated them. It has seemed to me that Mr. Clements has complied with the distinctive features of the scientific method as these are laid down in Karl Pearson's *Grammar of Science* :—

(1) The careful and accurate classification of facts and observation of their correlation and sequence;

(2) The discovery of scientific laws—a scientific law being, as he defines elsewhere, the brief formula, the words of which replace in our minds a wide range of relationships between isolated phenomena;

(3) Self-criticism and the final touchstone of equal validity for all normally constituted minds.

By these three steps of (1) unprejudiced collection of facts, (2) the tentative deduction of the links connecting them, and (3) the rigid examination and testing of every theory propounded science, in the sense of exact knowledge based upon ascertained fact, can alone proceed.

If I did not enter upon this investigation in the spirit of that prophet of ancient days who was engaged to curse a hated people and, instead, blessed them altogether, I, certainly, concluded my investigation into the Clements theories by believing them altogether. As consequence, I make known that which I have learned. I publish the theories, with the evidence in their support, as they have commended themselves to my judgment. Whether what convinced me will convince others, remains to be seen. I assuredly did not permit my judgment to be 'rushed.' On the contrary, thinking that if

[1] Art. Science and Mysticism,' F. Legge, p. 314, *Academy and Literature*, September 27, 1902.

Mr. Clements could explain some incidents in particular branches of terrestrial phenomena by his system he ought to explain all cognate instances, I submitted him to several tests. When we were talking of earthquakes and volcanic eruptions, I asked him to account for the Lisbon earthquake of 1755 and the eruption of Vesuvius which destroyed Herculanæum and Pompeii in A.D. 79. I received as answer to my inquiries the candid statement that Mr. Clements would willingly give me all the particulars I wanted, but he must be excused so far as Pompeii and its sister city were concerned, as the task of following the moon in all its perturbations for nearly two thousand years into the past was a task not to be accomplished in the time at his disposal. The Lisbon particulars are in Chapter III.

Coming to more recent times, and taking the phenomena recorded in a lately published book on meteorology, I put further questions to Mr. Clements. I had Allingham's *Manual of Marine Meteorology*[1] by me. This is a work which, I believe, is to be found in the officers' library of every important steamship; I know it is among the authorities accepted in the Peninsular and Oriental service. On page 80 is to be found a reference to the storm in which the *Royal Charter* (and nearly 350 other vessels) were lost on the coasts of England in 1859,—one of the earliest sea disasters which, owing to special reasons, was

[1] Charles Griffin and Co.'s Nautical Series, London, 1900.

imprinted on my own memory. 'How do the relative positions of earth, moon, and sun apply to that storm?' I asked Mr. Clements. In a few days I received this reply:—

'Royal Charter storm on morning of October 25, 1859, at 5h. om.

Transit	Parallax.	Moon Dec.	Sun Dec.	Difference.	Moon.	Sun.
noon	59·4	12°12′S	11°56′S	0·16 24·8	90°	80°

'Moon transits at noon; crosses meridian with sun on the 25th.

'Parallax 59°·4, nearly maximum parallax, and moon and sun's declination, both about 12°.

'Moon at five o'clock on morning of 25th at 90°, most effective position, and sun about 80° from seat of storm.'

Again, on page 32, under the heading of 'High Seas, Submarine Tremors, etc.,' Allingham reports several occurrences of enormous waves in otherwise smooth waters causing great damage to vessels. If the Clements theories, as I understand them, be correct, the 'pull' which lifted the waves should come from the conjunction of moon and sun in a particular position in relation to the earth, and, possibly, could arise from no other cause. I copied the following paragraph and sent it to Mr. Clements:

'In October 1881 all hands but one, a sick man below in his bunk at the time, were washed overboard by a sea while shortening sail in the North Atlantic. On March 28, 1893, the barque *Johann Wilhelm* had a precisely similar experience. The solitary survivor, in

each case, was eventually rescued by a steamer. On July 18, 1886, in lat. 40° N., long. 32° W., a tremendous solitary sea, coming along at a rapid rate, exactly like a bore in Calcutta river, rolled over the *Khyber*, doing considerable damage. On January 15, 1896, the steamship *Thermopylae* came up with three heavy swells into which she pitched the forecastle clean under. Before and after the sea was as smooth as a millpond, and a light southerly breeze prevailed. On March 3, 1896, in 48° N., 8° W., while hove-to in a westerly gale, the steamer *Cascapedia*, Captain Kerr, was seriously damaged by a solitary sea which swept completely over her. It rose up amidships in the hollow of the true sea, and rushed at the after part of the ship with great speed. In form it was a pyramid, fully fifty feet high, with a flat foam-crested top. On December 23, 1896, in lat. 39° N., long. 73° W., during a north-west gale, a high and broken sea struck the steamer *Madeline*, Captain Zurnedden, which nearly threw her on her beam ends. The vessel rolled so much that the steering compass turned end for end, the lubber points showing aft.'

In his reply Mr. Clements gave me much information concerning each phenomenon, so far as the facts stated were sufficiently definite. I deal here with one of the explanations only :

Transit.	Parallax.	Moon Dec.	Sun Dec.			Moon.	Sun.
9·44	57·4	19°42 N	3·11^{n}	16·31	22·53	90°	62°

The high wave in the North Atlantic, 50° N., 30° W., should have been produced at forty-four minutes past four on the morning of March 28, 1893, as resulting from the nadir lunar and solar tide at 90° and 62° respectively from the North Atlantic. The time at which the *Johann Wilhelm* encountered the wave is not stated.

Allingham (p. 80) tells of one of the most destructive cyclones of recent years, which he calls the 'blizzard' of March, 1891, 'which reached the British Isles without warning. Nearly thirty coasting craft, of from thirty to three hundred tons register, were subsequently posted as missing in consequence, and several fine ships were driven on shore along the South-West coast of England.' '"Without warning,"' you see it is stated, Mr. Clements,' I remarked; 'could you, by searching, have found out, before the calamity occurred, that the luni-solar "pull" would have enabled you to indicate that danger might be expected at this particular time?' For answer I received the following explanation:—

	'Transit.	Parallax.	Moon Dec.	Sun Dec.	Difference.	
9/3/91	—	61·20	14·32 S	4·29 S	10·3	19·11
10/3/91	0·19	61·20	8·30 S	4·5 S	4·25	12·35
11/3/91	1·13	61·00	1·58 S	3·42 S	1·46	5·40

'Moon new on 9th, 23h. 51m.; practically new on 10th; at noon moon and sun crossed meridian together, the 10th being the centre for 9th and 11th.

'Maximum parallax, 61° 20″.

Centre of Blizzard.	Parallax.	Moon Dec.	Sun Dec.	Difference.		Moon.	Sun.
17h.0m.	61·22	10·23 S	4·19 S	6°4′	14°42′	90°	81°

Centre of blizzard at 5 o'clock on morning of March 10, 1891. Parallax at a maximum; moon, 10° 23′ S. declination; sun, 4° 19′ S. declination. Moon, 90° from East Coast of England, and sun 81° from East Coast. When the moon was horizontal, the disturbing force at 90° ceased, and the force would be at a maximum.'

Nothing of a special character, I submit, remains to be added to commend Mr. Clements' work to an interested public. He possesses the greatest of all merit in such a matter, namely, that his predictions have the satisfactory habit of coming out accurately, or as near to accuracy as most things human can be, certainly more accurately than the tides; further, he never shrinks from any test in reason, which, with a sincere desire to ascertain the truth, may be put to him.

As to the general question: If the Clements theories be true, what (1) do they mean by way of beneficence in the protection of mankind from some, if not all, of Nature's great outbursts; and (2) of addition to wealth and the lessening of anxiety and trouble in enabling the agriculturist to adapt his operations to the particular kind of weather to which his land will be subjected? The question may be asked; it cannot be answered fully. Approximations, at the least showing enormous gain, may be made by those curious on such a point. It is said, of the mischances which a farmer in England has to encounter, that eighty per cent. owe their origin to adverse weather influences. By a proper understanding of those laws of Nature which Mr. Clements has made clear, and the frequent and wide diffusion of the knowledge thus gained, the occupation of the farmer might be made as reasonably certain as is the manufacturer's;

that is to say, it would become subject only to the competition of the markets. In respect to weather conditions almost more than to any other mundane affairs, to be forewarned is to be forearmed. In the States of the American Union, in the years 1889 to 1898 inclusive, nearly fifteen hundred lives were lost through tornadoes, while the damage done was valued at $24,633,750. Each of these tornadoes was predictable. If all of these tornadoes had been predicted some time ahead, the lives that were lost could have been saved; whether much property might have been preserved is, however, doubtful.

A contemplation of the beneficial possibilities growing out of a foreknowledge of the weather, not only in general outline but even in detail, for a long period, is followed by the belief that the gain would be wellnigh infinite. I leave the topic with a mere expression as to the magnitude of the benefits sure to be secured. For, as I hold, Mr. Clements has discovered, and, if there be any value in evidence and in repeated success in prediction, has furnished ample proof that he has discovered those hidden laws of Nature concerning weather phenomena which, once discerned and intelligently applied, turns meteorological chaos into natural order. A dozen years ago, when writing in the *Encyclopædia Britannica*[1] on

[1] Ninth Edition, p. 264. The emphasized clause in the sentence receives its emphasis from the present writer and not from Sir Archibald Geikie.

barometrical pressure, Sir Archibald Geikie said: 'Unequal and rapid heating of the air, or accumulation of aqueous vapour in the air, *and, possibly, some other influences not yet properly understood,* give rise to extreme disturbances of pressure, and consequently to storms and hurricanes.' Mr. Clements shows what these 'other influences' are, and proves that they affect the barometer when it rises or falls to a minute extent as well as when its movements are rapid and considerable. Professor Bonney (the latest of authorities on volcanic eruptions), in his work on Volcanoes, desiderated a further discovery or discoveries to clear up the mystery of the exciting cause of eruptions. I submit he will find what he wants in Mr. Clements' observations. Professor Milne wanders wide in his search for a clue to earthquakes, for that clue which shall reconcile the many and often contradictory theories with which he is confronted. To me it seems that the reconciler of all his doubts is to be found in the simple and efficient causation which the luni-solar 'pull' provides. And, as I observe the difficulties with which Professor G. H. Darwin, in his researches on the tides and cognate atmospheric movements, finds himself beset, they appear to pass into nothingness, and all the complex problems he lucidly discusses without always finding the right conclusion, become plain, with all doubts resolved, under the application of the moon's constantly exerted

attraction—now in large measure, now in less—as described by Mr. Clements.

I claim for this discovery that it solves existing problems in relation to the weather, and that, in its working, there is exhibited that simplicity, harmony, and movement, characteristically exerted along the line of least resistance, which mark every one of the great laws of Nature with which man has become acquainted. Further, I claim that I am advocating no unproven speculation, but that I am submitting a theorem fully demonstrated on the lines of strictly scientific research. The evidence produced for it should, I consider, be of 'equal validity for all normally-constituted minds.'

I pray for Mr. Clements' discoveries the most exhaustive examination, without prejudice and without passion, and I venture to urge that, if they be found to be true in their application, the good of humanity—especially in India—may lead to their early adoption in practical weather forecasting.

I have to thank Mr. W. R. Hearst, of the *New York American and Journal*, and Messrs. Arthur C. Pearson, Ltd., London, for permission to use Professor Serviss's diagrams of volcanic action, whilst students of terrestrial phenomena will share my indebtedness to Miss Annie A. Smith for the exhaustive index she has prepared. Of Mr. Clements' readiness to meet whatsoever

obligation I put upon him to satisfy my doubts and to comply with the thousand and one requests I made to him to clear up this, that, and the other, seeming contradiction, I cannot too strongly express my appreciation. He has sought no short cut to a conclusion, but has, unweariedly, plodded along the course of verification with results achieved that, honestly and unbiassedly examined, must, I think, bring conviction to every seeker for facts on which to establish verified truth. He has done that which, in Wordsworth's words, should be done by all students in that he has trusted

> 'To the solid ground of Nature'

in all that he has built.

LEINSTER MANSIONS, HAMPSTEAD, N.W.
November, 1902.

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1 AUGUST 1897

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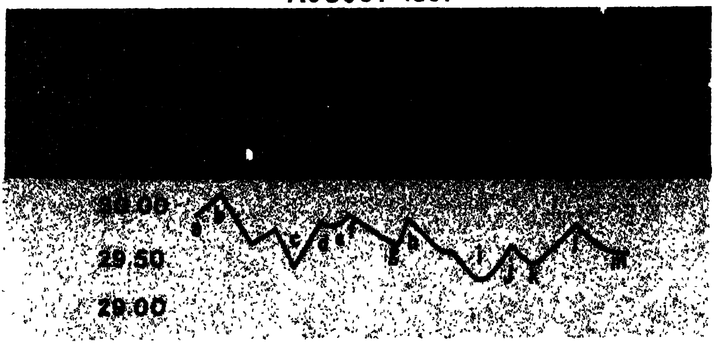

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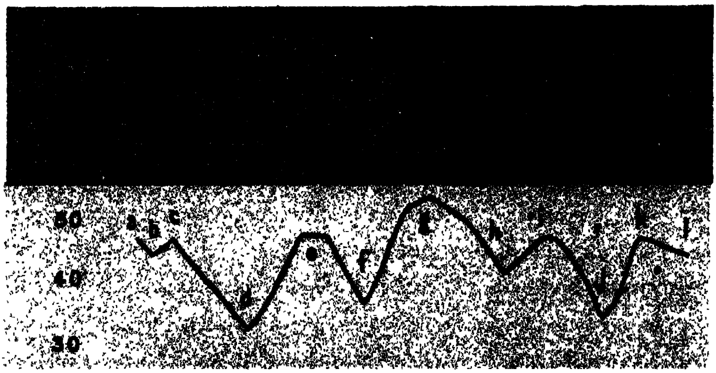

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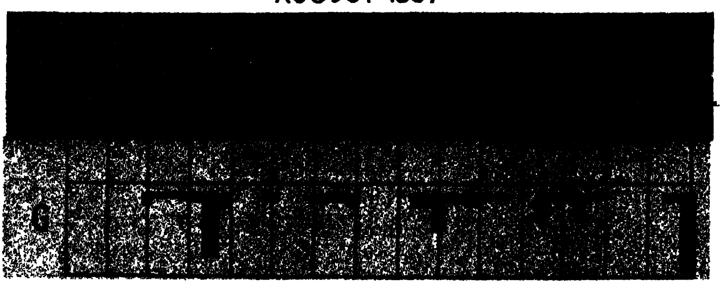

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PRELUDE

The Main Thesis of the Work.

The Discovery Evolved in Ordinary Scientific Sequence.
Mistaken Ideas concerning the Moon's Influence: Professor Cleveland Abbe's Dogma.
Limitation by Scientists of the Attractive Force of the Moon.
Dim Opinings of the Facts:

James Glaisher	Mr. G. D. Brumham
G. Dines, F.M.S.	Mr. Pliny Earle Chase
Herr Schübler	Major H. E. Rawson
M. Delamark	

The Astronomer Royal of England on Declination.
Investigations herein Recorded a Completion, and not a Destruction, of existing Scientific Research and Observation.

They say,
The solid earth whereon we tread
In tracts of fluent heat began,
And grew to seeming-random forms,
The seeming prey of cyclic storms.
—TENNYSON.

THE main thesis of this work is not wholly novel. No new truth in science ever springs, Minerva-like, full-fledged into being. The flooding of the world with light when the sun is fully risen is but the final act in a drama which begins with a faint horizon gleam that grows and grows until the day is fully born. Every advance in intellectual achievement is based upon what has already been gained, albeit, at first, it is made tentatively and often proceeds along the wrong line. A scientific truth is frequently apprehended in its effect—though not in its mode—by the average mind, before it has been

discerned in all its relations by, and made palpable to, a mind trained to observe and to reason. And, it not infrequently happens, an insufficient apprehension of facts, even by the trained and reasoning mind, makes the underlying truth seem impossible of realisation. Important factors, from some cause or other, are overlooked, and the conclusion becomes lame and impotent. In nothing, perhaps, has this fact been so markedly apparent as in the part borne by the sun and the moon in the causation of terrestrial phenomena.

Again: things on the surface and, therefore, readily discernible to the eye, are treated as if they were the whole of phenomena, as if that which was unseen did not exist. For example, the sun's heat is a palpable factor in the meteorological conditions of the earth's atmosphere. Men feel the heat; they cannot weigh it, they do not exactly know what extent of influence it exerts, but, because it is something which is palpable, something which is potent and which vividly appeals to their minds along the nerves of sensation, solar heat is regarded as combining in itself everything which is understood in the term weather. The moon radiates no heat which can be felt; therefore, the moon has nothing to do with the weather. Dr. Cleveland Abbe, of the Weather Bureau at Washington, when under cross-examination, in August, 1902, concerning the cause of the strange weather of the summer of that year, said:—'We know that it isn't the moon.'

Solar heat, say the scientific authorities of the day everywhere, is sufficient to account for all the vagaries of climate.

They do not say this of other phenomena—of the causation of the daily tidal ebb and flow, or of the bi-monthly maximum rise and minimum fall of those tides. They treat the moon as a negligible quantity. Why?

Looking about them men saw the waters of the ocean

rise responsive to the moon's attractive force. They saw with the visible eye those waters move in harmonious sequence, and they were satisfied as to the attractive power of the earth's satellite; in the tides which rise and fall they beheld the finger of Nature writing in imperishable characters the fact of unseen and (humanly) unfelt influence bringing about mighty results.

The attractive force of the sun, the earth, the moon, of every solid particle upon every other solid particle, was, in like manner, accepted as a truism in scientific thought and speech; its effect was seen to penetrate to the remotest corner of the visible universe to which the telescope could pierce or which the photographic lens could detect. That force could not be denied.

But, chiefly, I suppose, because they have become so much habituated to the movements of the atmosphere in which they live and move and have their being, men have been loth to comprehend that solar heat is, at the best, but a subordinate element in a complex array of forces, in which the chief part is played by precisely those same attractive forces which, in relation to grosser matter, they could see and weigh and almost handle, and that these were really the controlling influences in the causation of terrestrial phenomena. Yet Helmholtz 'has shown that sea-waves of ten yards in length will correspond with air-waves of as much as twenty miles.'[1] This single statement should have revealed to all students of climatic conditions what is the fact, namely, that the influence of moon and sun on the earth's atmosphere was, after allowing for the difference in density, many times greater than on the waters which cover so large a part of the face of the earth. Owing, it may be, to their prepossessions, men's eyes were holden so that they could not see.

Throughout all this negation, the moon, in the minds

[1] Professor G. H. Darwin, p. 46, *The Tides*. John Murray.

of many people, nevertheless remained a controller of the weather. How much, how little, was not insisted upon. It did something. Even veterans in the ranks of orthodox meteorologists confessed to sharing this view, and applied themselves to the ascertainment of what the influence really was. Unhappily, the observers confined themselves to the various phases of the moon, regardless of all other considerations, and, naturally, failed to find the solution of the difficulty. They confessed themselves—now one way, now another. Mr. James Glaisher, for so many years associated with meteorological research, said, nearly fifty years ago:—

'Whether we take the amounts of rain fallen or its frequency, both lead to the same conclusion, viz., that the position of the moon in respect to her age, does seem to exercise a sensible influence both on the frequency and amount of rain.' [1]

On the other hand, Mr. G. Dines, F.M.S., basing his opinion on journals kept at Cobham, Surrey, and the Royal Horticultural Gardens, Chiswick, for the thirty years ranging from 1825 to 1865, declared:—

'I am, notwithstanding a strong prejudice to the contrary, obliged to come to the conclusion expressed in my previous paper, "that the fall of the rain is in no way influenced by the change of the moon or the moon's age."' [2]

I believe that the succeeding pages of this book prove

[1] *Proceedings of the Royal Meteorological Society*, vol. iv. p. 348.

[2] Other gropings after the truth might be mentioned, among them the following:—

(1) 'Schübler measured the quantity of rain at Augsburg from 1813 to 1828, . . . examined the influence of perigee and apogee . . . rain was seven per cent. more frequent when the moon was nearest to the earth than when at its greatest distance.'—*Symon's Monthly Meteorological Magazine*, 1868, p. 84.

(2) 'M. Delamark observed that when the moon is going from the south declination northwards, the wind is north, the weather is fine, and the barometer is high; when the moon is going from the north declination southwards, the wind is south-

that the moon's attractive influence exerted upon the earth's atmosphere, in conjunction with the sun, accounts, in the main, for all weather phenomena. Nevertheless, we, who are responsible for the presentation of this discovery, say with Mr. Dines: 'The fall of rain is in no way influenced by the change of the moon or the moon's age.' The transition from the actual curve of the crescent moon, the departure from the straight inner line of the half-moon, the more pretentious curve of the gibbous moon, the perfect maturity of the full moon—a change from any one of these was held to influence the earth's atmosphere. It was as if it were supposed that

erly (sometimes strong), there is rain, with a low barometer. These rules are most closely followed when the moon is at some distance from the equinoctial and in perigee.'—*Ibid.*, p. 85.

(3) Mr. G. D. Brumham, writing to the same magazine (pp. 104, 105), says: 'I am prepared to prove that the declination influence of our satellite is very great. . . . Till the year 1860 I entirely disbelieved in the moon's influence on the weather, and ridiculed the theories put forward; but in that year phemonena occurred which induced me to examine the subject with some care; seven years' investigation . . . converted me; I have become a lunarist in spite of my prejudices and almost against my will.' Again: 'I stated that "perigee and apogee positions of the moon with regard to our meridian as well as the perigee of the sun, have an extremely important influence on the rainfall." I will now endeavour to prove this statement. . . . The foregoing meteorological rules appear infallible. Certainly they have never failed since 1833. This is very satisfactory. For, as these laws depend upon the positions of the sun and moon, which can be calculated many years before they occur, it is evident that the periods of drought and fine weather which they cause may also be predicted for many years before they happen.'—*Ibid.*, 1869, p. 59.

(4) On the same subject Mr. Pliny Earle Chase said: 'The influence of the moon on the ocean tides, on the fluctuations of the barometer and the magnetic needle, and on the winds, are so well known that the inference of a similar influence on rainfall seems almost irresistible. I was so startled at Mr. Dines' conclusions, that I was led to examine into the correctness of his methods.'—*Proceedings of the American Philosophical Society*, June 19, 1868.

the moment of change from any one of these conditions differed in some miraculous respect from any other momentary change in the aspect of the moon to the earth. It is, of course, the fact that there was no magic in the period from quarter to half-moon that was not present from new moon to quarter-moon, and so throughout the whole lunar period. Changes of weather apparently often coincided with these changes in the moon, but the cause lay in something very different from an orderly movement which, in itself, was precisely the same from the first faint line of light to the last glimmer of light in a lunar life, and so on again as the last glimmer insensibly slid into the new light and the new life.

Two steps further in the direction of the *veræ causæ* of phenomena were taken when Major H. E. Rawson, R.E., a Fellow of the Royal Meteorological Society, read papers before the Society in December 1895, and in April 1896. He examined the Greenwich rainfall records from 1879 to 1890 with special reference to the declination of the sun and moon, and stated the outcome of his examination. He confined himself to declination only; had he taken parallax and some other considerations into account his conclusions would have been as conclusive as they were really inconclusive. He found that in ten years out of the twelve under consideration the mean height of the barometer at Greenwich was higher when the declination of the moon was south than when it was north; that, in the same period, it was higher when both sun and moon were south than when they were north, and that there was a distinct tendency of the rainfall to follow the barometer. Had Major Rawson been familiar with Mr. Hugh Clements' work, freely available at that time, he would have found what would have resolved all his doubts, and would have made clear to himself and to those who

discussed the position with him, what was obscure. In the course of his reply to critics, Major Rawson said:—

'. . . the Astronomer Royal had for seven years carried on an investigation into the influence of the moon's declination on the barometer, and had found in several years that the mean height "seemed to be increased by the moon's position in the south declination." '[1]

[The inadequacy of a comparison of the barometer or the weather for similar declinations of the moon or sun alone, without taking into consideration the other factors in the production of phenomena, finds striking confirmation in the following particulars:—

	Bar.		Bar.
11/1/1883	29·44	11/1/1901	29·93

With a difference in barometer of ·49 in. there could be no similarity in the weather. Yet, strange to say, on these dates the declinations of the moon and sun were the same.

11/1/1883	moon's declination	9°8′ S.	sun's declination	21°52′ S.
11/1/1901	,, ,,	9°8′ S.	,, ,,	21°52′ S.

·20 in. of difference in barometer was due to perigee, and ·30 in. difference of barometer was due to transit, thus:—

	Transit	Parallax	M. Dec.	S. Dec.	Difference		Bar.
11/1/1883	2·8	60·55	9°8′S.	21°52′S.	12·40	31·0	29·44
11/1/1901	17·24	54·14	9°8′S.	21°52′S.	12·40	31·0	29·93
Difference	15·16	6·41	0·0	0·0	0·0	0·0	0·49
Value	·30	·20					

·30 + ·20 = ·49 very approximatively.

Among other things made clear in these particulars is the intimate connexion observable between the large parallax and the state of the barometer. With parallax 60·55 the barometer stood at 29·44; with parallax 54·14 it stood at 29·93, allowing for transit.]

In the same speech Major Rawson went even nearer

[1] Vol. xxii. *Quarterly Journal of the Royal Meteorological Society.*

to the explanation of what had puzzled him and left his mind in an indecisive condition, when he said: 'Considered with respect to the sun and the earth the moon's motion, relative to any place on the earth, such as Greenwich, was very different indeed from year to year. Every fourth year, in consequence of the revolution of the moon's apsides, the apogee of the moon will occur where the perigee occurred before. Every fourth year the periods when the moon is north and south of the equator will be exactly reversed; during those days of each month that the moon was north of the equator it will be south, and vice versa. Considering the motion of the moon round the earth in an ellipse, which in itself is in a twofold state of motion—one of advance and one of tilt—it was a matter worth noticing in the period under discussion that in the eleventh year there was a similarity in the motion of the moon which does not appear in any other year.'

Much more testimony of a similar character to the above might be cited. Enough, however, has been quoted to justify the statement with which these preliminary observations will close. That statement is this:—

The results arrived at in the investigations hereinafter recorded, the conclusions which are submitted, are in no sense hostile to the great work of observation and record which the meteorologists of the United Kingdom have accumulated through many years of service. On the contrary they are the complement of that work in that they carry incomplete studies towards a completion and provide a sufficient explanation of the varied manifestations of terrestrial phenomena in the form of earthquakes, volcanic eruptions, wind storms of every kind, and rainfall—from the gentle shower to the cyclonic torrent.

The Problem of the Volcano and of other Phenomena

The Most Significant Incident in Martinique.
Sir Archibald Geikie on the Possibility of Forewarning of Volcanic Eruptions.
Inhabitants of St. Pierre Prevented from Escaping from the Doomed Region.
Optimism of Scientific and General Authority.
Mont Pelée 'no more to be feared than Vesuvius.'
Good Intentions and the Ruthlessness of Natural Law.
The Golden Key to Unlock the Door of Mystery.
Newton's Formula and Diagram.
The Man who Fitted the Key into the Lock.
Neglect of Modern Astronomers, Meteorologists and Geologists.
'Nelson's Blind Eye Everywhere.'
Scornfulness as to Moon's Influence by Recent Writers :
Croll in 'Climate and Time'
Abercromby in 'Weather'
Scott, 'Elementary Meteorology'
Waldo, 'Modern Meteorology'
Moore 'Meteorology, Practical and Applied'
Dickson, 'Elements of Weather and Climate'
Russell, United States' Meteorology
English Meteorologists and U. S. Weather Bureau alike Heedless of Moon's Tangential Power.
Sequence of Events in Martinique.
Nature's Invariable Warnings of Coming Changes.
Excursion to Krakatoa, and Picnicking on Mont Pelée.
'Pelée is snoring loudly.'
The Ameliorative Side of Volcanic and Earthquake Phenomena.
Professor Judd's Conclusions on the 'Compensating Agency' for Denudation by Frost, Rain, Wind.
Generally prevailing Ignorance as to the Final Cause of Terrestrial Phenomena.
Nature's Warnings, and her Beneficial Labours.

Laws which Govern the Tides of the Oceans and the Tides of the Air Identical.

Appendices:

I. Professor Shaler's Conclusions.
II. Mr. Robert Hill's Theories.

IF mankind were endowed with a sense of the right proportion which things essentially (though not always in appearance) bear towards one another, the most significant incident in connexion with the recent earthquake phenomena and volcanic disturbances in the island of Martinique would be that in which the Governor of the colony took so prominent (and so disastrous) a part. At the present time the incident provokes no comment. In sight of the terrorizing exhibition of Nature's upheaval of her internal fires, the consequent destruction of human lives and the razing out of the products of cultivation and the overthrow of city, town, and village, by which man had made this normal paradise of the Caribbean Sea a desirable place to live in, aught but the outward manifestation of Nature's seemingly harsh and destructive action seems to escape observation and comment. In a few moments of time a whole city was destroyed and tens of thousands of lives were blotted out, after many of the victims had endured grievous, if temporary, anguish. Once the movement of the earth's atmosphere had begun which relieved the pressure over Martinique and over the Antilles generally, no power of man could have preserved St. Pierre from destruction. Irresistible forces of Nature, at first in quiet, unobtrusive, fashion, were let loose; obliteration of city and plantation, of negro's hut and Governor's mansion, of the shrine of voodoo priest and of Christian cathedral, became inevitable. Nothing conceivable in the way of precaution could have averted the disaster or have stayed the course of the phenomena produced. In respect, however, to the human beings in the unfortunate city and its neighbourhood it was otherwise. Men,

women, and children—all might have been saved. With such foreknowledge as is even now attainable, turned to the provision of precautions, many would have been saved.[1] The mountain, which was to become the instrument of destruction, gave every one sufficient warning of the

[1] Two days after this passage was written I received the July number of the *Pall Mall Magazine*, in which appears an article by Sir Archibald Geikie on 'Volcanic Eruptions in the West Indies;' he therein says (p. 395): 'It cannot be said that the islands which have been the scene of the recent disasters were without ample warning that some serious outbreak of volcanic energy might be anticipated. But the signs were not understood, or passed unheeded, hope, as usual, triumphing over fear. . . . No one could have predicted that these symptoms' —'rumbling noises' in St. Vincent and Martinique—'were the prelude in each case to a gigantic and devastating explosion; but any expert acquainted with the ways of volcanoes would have been justified in issuing the most earnest warnings to have prepared for some serious outbreak, and to remove as far as might be from the immediate precincts of the volcanoes.' It is necessary I should state that it is not quite exact for Sir Archibald to say that 'no one could have predicted the gigantic and devastating explosion.' Mr. Hugh Clements could have done so. Had his researches (to be detailed later in this volume) into the earthquakes in India and in Great Britain during the past few years been properly noted, he could have predicted to the hour, almost to the minute, the catastrophe of May 8. Further (on p. 400) in the same article Sir Archibald Geikie makes some remarks which, it is hoped, may not be forgotten by him and others in authority in relation to the great security which may be obtained by the adoption of Mr. Clements' mode of dealing with coming natural phenomena, that is, of course, always supposing Mr. Clements is able to convince them as to the accuracy of his observations. If the accuracy be conceded his conclusions necessarily follow. Sir Archibald adds: 'There is one lesson which it seems to me should be taken to heart by those who have authority in such regions as the volcanic parts of the West Indies. Had there been any competent observer on the flanks of Mont Pelée, it is possible that, though St. Pierre would none the less have been destroyed, its population might, to a large extent, have been saved. Man cannot, indeed, prevent the internal commotions of mother earth, any more than he can interdict the storms of the air. But he can watch the oncoming of both, and can at least obtain some warning of their approach.'

grave peril which was impending over town and country. All the people, whilst yet there was time, could have been removed from the trembling streets, from the darkened and poisonous air, out of sound of the continuous premonitions of the coming catastrophe. It is not the fault of Nature herself that loss of life occurred. Nature issued storm-signals in plenty. Her fire-bells were continually clanging. Some of St. Pierre's inhabitants recognised them for what they were and would have escaped from the wrath to come. At this juncture courage on the part of the authorities—inspired, there can be no doubt, by an exalted sense of duty which, in itself, does honour to the Governor who displayed it—led to intervention. Nothing serious could happen,—so the people were assured. There would, perhaps, be a few more scares, smoke might continue to arise and ashes to be vomited, but only in minor measure; things would revert to their former satisfactory condition in a little while if only the people would be patient. So reasoned authority, and authority acted on its own reasoning, showing its belief in what it was doing by sharing in the peril involved. When the earlier manifestations occurred, and widespread alarm was experienced, the Governor of Martinique issued reassuring messages. These not sufficing to satisfy the people, who began to stream away from the doomed city, he himself, with his wife, proceeded thither. Troops were stationed in the roads leading from the city; acting under orders they turned back those who would have found their way to comparative safety. He also called for a warship to go to St. Pierre to aid him: the order was received, but too late to be of service. Regarded with the knowledge now available, the incident furnishes, perhaps, the most tragic example in history of well intentioned, but nevertheless ignorant and mistaken, executive action. The blameworthiness, if such it were, of the authorities was shared by the exponents of public

opinion. The newspapers to the last derided the possibility of any serious consequences—did so even when plantations had been blotted out of existence and lives had been lost. On May 7, the day before the terrible outburst which wiped out St. Pierre as with the sweep of an Almighty hand, 'M. Landes, the distinguished Professor of the Lycée,' a leading scientist of Martinique, contributed to *Les Colonies*, 'organe Républican de la Martinique,' a learned article on volcanoes, and was interviewed at the same time. After discussing the mischief done until that time, the Professor thus concluded his observations :—'Vesuvius has never made many victims. Pompeii was evacuated in time, and few bodies have ever been found in the buried cities.' Conclusion: 'Mont Pelée is no more to be feared by St. Pierre than Vesuvius is feared by Naples.' [1]

Later, towards the end of August and early in September, when the eruptions of May were repeated—at the time and in the manner predicted by Mr. Clements in May—the same official foolishness was exhibited, and once more the hand of authority held the people back when they would (and could) have escaped from the doomed area.

The only excuse to be urged for the Governor of Martinique, in condemning the people he ruled to a swift ending of their lives, is his ignorance. He meant well. He was evidently strongly desirous to do the best he knew for the people under his control. Nature, however, takes no heed of good intentions. If her warnings are neglected, the last penalty for neglect is exacted. This is a rule in all natural phenomena, a rule without variation, without the shadow of a variation. It was less the fault of the Governor himself, seeing he was unable to read the plain lesson writ in such startling characters across the sky,

[1] 'The Last Days of St. Pierre,' *Century Magazine*, August 1902.

than of the scientific investigators of the nineteenth century. The cause of such phenomena had long been plainly discernible if men of science would but have looked in the right direction for it. As will be seen again and again in these pages, dim glimmerings of the truth caught the vision of a few observers, but none saw that a flood of Nature's own light was awaiting a trained and observant gaze. Yet the exhibition of as much curiosity concerning the disturbing influence of the moon upon the earth as Adams and Leverrier devoted to the perturbations of Uranus would have given to astronomers the golden key with which to unlock the closed door. Sir Isaac Newton, in his day, had shown the nature of the moon's influence, but none heeded his meaning so far as to apply that influence in every conceivable way. Had not the familiarity which, even in regard to the heavenly bodies, breeds something of contempt, led astronomers to consider that pretty well all there was to be known concerning the moon was already known, the fact would long ago have been ascertained that one of the most potent powers in the universe, so far as mankind is concerned, lies in the great tangential pull upon the earth exercised by the moon (as to two parts) and by the sun (as to one part) on the earth's crust and oceans, and, more important still, upon the earth's atmosphere. The extent and manner of this pull will be better judged by a diagram and technical description, as shown on the next page (Fig. 1).

Let M and E denote the moon and earth, and A any particle of matter on the earth's surface. Newton's contention is :—Let A C be drawn perpendicular to E M, and let E F be measured off equal to three times E C, and let A F be drawn. This line A F represents, in magnitude and direction, the disturbing force of the moon, M, upon the matter at A, the moon's attraction upon the earth being represented by the line M E.

If the disturbing force A F be resolved into A N and A T in directions coinciding with the radius of the earth and tangential to it, A N will represent the part of the moon's

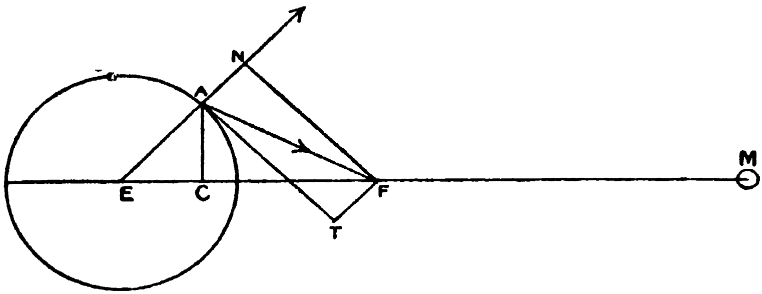


FIG. 1.

force which lifts the matter and is called the normal component ; and A T the part which draws the matter towards the line E M, is called the tangential component. The tangential component is effectual as it acts at right angles to gravity, and is therefore unopposed by it. The normal component is in opposition to the weight of the matter, and produces no appreciable effect. The tangential component varies as the sine of twice the altitude of the moon or sun, and when the altitude of these luminaries is 45° the force is at a maximum.

Here was the key. For two and a half centuries it had been discoverable. Newton, to the initiated, should have been understood to clearly indicate it. Yet not one amongst the eminent and endowed men of science has discovered it. The discovery was left to an earnest student of natural phenomena, if haply he might find the why and the wherefore of the changing seasons ; it was left to such an one to discover the key and to place it in the lock which none had yet forced, which all but a few hopeful men had declared could never be fitted and turned. To Mr. Hugh Clements, an Ulster Irishman from County Down by birth and upbringing, humanity owes the new applica-

tion of knowledge which, properly employed, will make earthquakes and volcanic eruptions, both great and small, as accurately to be foretold as are the eclipses of sun and moon and earth. Nay, these things are but as the small dust in the balance compared with the great benefits which will be gained for and by mankind once it is realised that the tides of the atmosphere, with their resultant storm and calm, rainfall and drought, are more surely and more accurately predictable than are the tides of the ocean and their rise and fall in the commercial ports of the world. For, with the Clementian knowledge turned to daily account, the mischances of the farmer in every region of the globe may be greatly minimized, and in some instances wholly avoided. In Europe and in the United States of America intelligent cultivators may prepare their land and grow their crops—sowing the seed or planting the bulbs of certain cereals and roots, strictly avoiding the planting and sowing of other seeds and plants —with as much certainty as the compass-directed mariner sails from port to port or the pilot brings the homeward bound vessel into port in spite of the sinuosities and silting-up of river channels and takes the same vessel out once more into deep waters. In India, so far as famine there is a consequence of drought, famine may be made impossible. How all this may be brought about will be shown in due course.

These preliminary observations may be carried a little farther so as to sustain the argument in preceding pages to the effect that knowledge of the meaning of Nature's warnings as to what she intended to do might have preserved the lives of the inhabitants of St. Pierre. [The same assertions, *mutatis mutandis*, apply to St. Vincent and La Soufrière as to St. Pierre and Pelée, like conditions existing in each instance.]

The neglect of modern astronomers, meteorologists, and geologists to take account of the moon in the determina-

tion of the causes of terrestrial phenomena is so surprising as in a student's mind to cause a feeling of bewilderment. Nelson's blind eye is everywhere. And yet it is not possible to say that the blind eye of eminent scientific observers is wilfully turned towards the moon. But the attitude assumed is inexplicable. Take Croll's most learned treatise on *Climate and Time in their Geological Relations*:[1] from the first page to the last—save in Appendix VIII. (p. 562) in the titles of two Papers —the moon is not once mentioned. Everywhere the sun and its influence in causing climatic change are obtruded. The part which, undeniably, the moon must have played throughout the vast periods required in Croll's teaching concerning the secular changes in the earth's climate, is wholly ignored. And yet, closely studied and all the facts taken into consideration, the probabilities are that the moon's influence, particularly when exerted in connexion with the sun, has played maybe the greater part in bringing about the climatic changes which the world has known and which the geologist has made palpable. It is not easy to imagine how great a change would be needed in the argument and illustration of the Crollian discovery if due heed were given to what the moon was doing in the four millions of years with which that author deals.

As with Croll so with pretty well all the others. Abercromby[2] is neglectful of the lunar influence. To him the moon is a negligible quantity. It may, with impunity, he considers, be disregarded. In this respect he was but following in the wake of Mr. Robert H. Scott, of the Meteorological Council, the author of the weather-charts and storm-warnings which, consequently, give so

[1] Edward Stanford, 1897. Fourth Edition.

[2] *Weather: a Popular Exposition of the Nature of Weather Changes from Day to Day*, by the Hon. Ralph Abercromby. Int. Sci. Ser. Kegan Paul, Trench, Trübner & Co., 1897.

little satisfaction to an interested public. All the use Mr. Scott finds for the moon is, on p. 53 of *Elementary Meteorology*,[1] to make a passing reference to the heat received by the earth from its nearest companion, and on p. 203 to allude to 'mock moons,' phenomena of occasional occurrence. To teach meteorology, and to omit all consideration of what the moon does in the making and marring of daily weather, is to teach the alphabet and to treat the vowels as though they were non-existent. As the words of human intercourse, *sans* vowels, would be a meaningless jumble of sounds, that, because of the ignoring of the moon in weather conditions, is what meteorological 'science' has become. So completely has meteorology become a merely monotonous 'marking time' while every other science is progressing, that the weather prophet of the Contemporary Science Series treads in the footsteps of his brother of the International Scientific Series—each one closely imitates the other. In *Modern Meteorology* [2] not even a 'mock moon' is introduced. The Sanitary Series follows suit. *Meteorology Practical and Applied* [3] contains a large number of closely printed pages, but the moon nowhere throws any light on the problems considered or the practices described. With Methuen's University Extension Series [4] the sequence is broken. Mr. Dickson devotes less than fifty lines to a consideration of the 'belief that changes of the moon occurring at particular times are followed by special types of weather': this belief is 'so strong and so widespread' as to demand special notice. A table prepared by

[1] *Elementary Meteorology*. Eighth Edition, Int. Sci. Ser. 1899.

[2] *Modern Meteorology*, by Frank Waldo, Ph.D. Walter Scott, Limited. The Contemporary Science Series, 1893.

[3] *Meteorology: Practical and Applied*, by John William Moore. Rebman. Sanitary Series, No. 1, 1894.

[4] *Meteorology: the Elements of Weather and Climate*. By H. N. Dickson. Methuen. University Extension Series, 1893.

'the older Herschel' is submitted, and the conclusions upon which it is based are declared to be '*a priori* absurd,' an opinion with which the present writer concurs. Mr. Dickson evidently considered that, as the 'older Herschel' had spoken, albeit unwisely, no more was to be said. For himself he departed hastily into another region.

Some American meteorologists are no better. In August 1902, Professor Cleveland Abbe, of the American Weather Bureau, Washington Office, referring to the abnormal summer weather, declared the moon had nothing to do with it. 'We haven't,' he said, 'the slightest notion as to the cause of this summer's extraordinary weather. We know that it isn't the moon, and that it isn't sun-spots, but what it is we are utterly unable to say.'[1] More respect is paid to the moon by another American.[2] Mr. Thomas Russell, in the introductory chapter to his book, discourses on broad lines upon the alleged influence of the moon on the earth's weather. He considers, however, that all attempts to 'show a connexion between the moon and the weather' 'have signally failed.' He is quite right so far as the evidence with which he deals is concerned, seeing he deals only with the moon, and with the moon at its changes. Once he stumbled on the threshold of the door leading to the house of knowledge when he said: 'The moon must cause a tide in the air as well as in the ocean, and it seems reasonable that it might have some influence on the weather, though very small.' Instead of following out the line of research thus indicated he takes refuge in the attitude of disapproval or open con-

[1] Interview in the *New York American and Journal*, Aug. 17, 1902.

[2] *Meteorology: Weather, and Methods of Forecasting, etc.*, by Thomas Russell, U. S. Assistant Engineer. New York: Macmillan & Co., 1895.

tempt which 'scientifically qualified persons' assume 'towards the belief in the moon as affecting the weather.' 'This,' he asserts, 'is not grounded on sufficient examination in most cases, but is largely the result of prejudice, . . .' Mr. Russell's further observations, because of the comparative open-mindedness he exhibits, deserve quotation, and will be found at the foot of this page.[1]

Citations similar to the foregoing might be multiplied very greatly. Enough, however, has been stated to show the utter neglect by English meteorologists of the moon's place in weather production, and the absence of serious consideration on the part of the chiefs of the American Weather Bureau. The neglect and the care-

[1] 'Weather records for a number of places that have been examined show that there is a somewhat greater tendency to rain in the quarter after full moon than at other times; there is a greater probability of rain with the moon in perigee than apogee. There is no doubt in regard to this relation of the moon and rain, but the difference is not known even approximately, and it varies for the different parts of the earth. It is of no practical value for weather prediction. Attempts have been made to show that there is less cloudiness at full moon than at other times. The results are contradictory for different places. The effect is either so small that the longest series of records does not show it, or it does not exist. The effect of the moon on the frequency of thunder-storms is inappreciable. As regards the winds, northerly winds are more prevalent during the last quarter of the moon, and southerly winds more frequent during the first quarter than at other times. No conclusion can be drawn in regard to the varying force of the wind for the different quarters of the moon. With regard to change of the weather and change of the moon in 5,000 cases examined, 1,800 showed a change of weather, and 3,200 no change.

'The effect of the moon on the pressure of the atmosphere is very slight. There is an ebb and flow that is only perceptible near the equator by the most refined instrumental means of observation. The difference between the least and greatest pressure due to the effect of the moon is only 0·004 of an inch. The pressure of the air is probably greater with the moon farthest from the earth, and greater at quadratures than syzygies. No predictions of weather of any value can be based on pressure variations due to the moon.'—*Ibid.* p. xviii.

lessness are responsible for the slight credit which attaches to meteorology as a science.

At this point the reader will please assume that the occurrences in Martinique were predictable. Was there enough warning to allow of the salvation of the many thousands of people who perished in so untimely a manner ? The sequence of events, as recorded by one of the most eminent of geologists, and assuredly one of the most advanced students of seismology, answers the question in the affirmative in the following statement :—

SEQUENCE OF EVENTS[1]

WEDNESDAY, APRIL 23—
Three loud explosions underneath Mont Pelée:

THURSDAY, APRIL 24—
First signs of steam and smoke.

SATURDAY, APRIL 26—
Flames and heavy clouds of steam and showers of hot rocks. Tremors of the earth.

MONDAY, APRIL 28—
Repeated explosions like rapid-fire guns, smoke and steam.

WEDNESDAY, APRIL 30—
Bursts of flame and intermittent showers of hot volcanic dust.

THURSDAY, MAY 1—
Heavy explosions and small showers of hot ashes, with sulphurous smoke.

SATURDAY, MAY 3—
Rumblings, showers of boiling water, and increased smoke.

[1] Compiled by Professor Serviss for the *New York American and Journal.*

SUNDAY, MAY 4—

Showers of hot cinders and great column of sulphurous smoke growing higher.

MONDAY, MAY 5—

Sudden eruption of a river of boiling mud, which overflowed and destroyed Guerin's sugar factory; 27 killed.

TUESDAY, MAY 6—

Waterspouts out at sea; water in the harbour grows very hot; smoke, steam, and volcanic dust continue.

WEDNESDAY, MAY 7—

Fissures noticed on east side of mountain emitting jets of steam; atmosphere heavy with sulphur fumes, explosions more frequent and heavier; dense clouds of thick smoke, ashes, and dust, roll down mountain sides, killing birds, animals, and reptiles.

THURSDAY, MAY 8—

Deafening explosion at 7.50 a.m. splits off upper half of mountain; shower of ashes, cinders, and hot rocks of all sizes shot miles into the air; a surging, hissing, sea of white-hot lava pours out of the broken mountain, followed by a blinding whirlwind of burning gases which destroyed the city of St. Pierre, the shipping in the harbour, and the forests for miles around. A tidal wave of boiling water twice swept in and across the bay.

Another scientific authority thus describes the culminating incident:—

'MAY 8—At 8 a.m. "the rain of fire" destroyed St. Pierre. Ships were burned and sunk by a shower of rocks and heated materials which poured down for about fifteen minutes. At Fort de France, twelve miles distant, these stones were the size of walnuts.

'The eruption still continues, but, on the 10th, it had so

ar decreased that the site of St. Pierre was explored, but no living beings were seen.

'The eruption of La Soufrière in St. Vincent commenced on Monday, May 5, and on May 7 the eruption was violent.

'It would, therefore, seem that these two eruptions were simultaneous, and may have been brought about by a common cause.'[1]

Possibly it will be conceded by the reader that the 'common cause' of the eruptions is that which Mr. Clements describes in Chapter III of this work. Twelve days elapsed between the first manifestation of disturbance on Mount Pelée and the 'rain of fire' which destroyed city and shipping and quenched the life of many thousands of people. In Martinique, as in the Dutch Indies in 1883 when the great eruption of Krakatoa was in course of development, owing to the ignorance of learned and unlearned alike as to what was impending, the disturbances were regarded as objects of interest rather than as that descent to Avernus which they soon proved to be, and which a knowledge of the working of certain natural laws that Mr. Clements had already made clear would have foretold. Of the coming disaster at Krakatoa 'notable warnings were given. Earthquakes were felt, and deep rumblings proceeded from the earth, showing that some disturbance was in preparation and that the old volcano was again to burst forth after its long period of rest. At first the eruption did not threaten to be of any serious type; in fact, the good people of Batavia, so far from being terrified at what was in progress in Krakatoa, thought the display was such an attraction that they chartered a steamer and went forth for a pleasant picnic to the island.' 'Many of us, I am sure,' says Sir Robert Ball,[2] whose narrative I am quoting,

[1] 'The Recent Volcanic Eruptions in the West Indies,' by John Milne, F.R.S., F.G.S., in *Nature*, May 15, 1902.

[2] *The Earth's Beginning*, p. 177. Cassell & Co., Limited, 1901.

'would have been delighted to have been able to join the party who were to witness so interesting a spectacle. With cautious steps the more venturesome of the excursion party clambered up the sides of the volcano, guided by the sounds which were issuing from its summit. There they beheld a vast column of steam pouring forth with terrific noise from a profound opening about thirty yards in width.'

As in Java so in Martinique. No place in the latter island was so desirable for a picnic on a pleasant Sunday afternoon as the slopes of Mount Pelée. In the afternoon editions of St. Pierre's only daily newspaper (*Les Colonies*) on May 2 a 'display advertisement' headed 'Toward Mont Pelée' was published. It tells of a proposed trip two days later, the presumed attractiveness of which was such that the Gymnastic and Shooting Society, in arranging the visit, wished it to be understood 'that the usual target practice at the Botanical Gardens' would not take place. The advertisement was in these terms:—

'We call attention to the fact that on next Sunday, May 4, a grand excursion will take place to Mont Pelée, which has been organized under the auspices of the members of the Gymnastic and Shooting Society. This presents an unprecedented opportunity to those who have never enjoyed the opportunity of witnessing the magnificent panorama presented to the eye of the astonished spectator at an altitude of 1,300 metres.

'The excursionists will be enabled to witness close at hand the great chasm, which is still yawning, and through which have escaped during these last few days those thick clouds of smoke and steam which have not failed to cause alarm to some of the more timid of our residents. All who desire to profit by this grand opportunity should see that their names are enrolled at once in the office of the society not later than this evening.' [1]

In later issues of *Les Colonies* particulars are given

[1] Correspondence of *New York Herald*, June 1, 1902.

which show that the excursion was largely attended, but that the excursionists were unable to see much because of the dense volumes of steam wreathing the mountain-top. The report states, however, that 'they tramped all day through thick dust, which looked like the grey flour of America.'[1]

Thus, given that intelligent anticipation of events to ensure which all knowledge tends, and the certainty of a maximum development of energy attending the conjunction of moon and sun on May 8, in a position boding seriously for Martinique, practically no death need have occurred in St. Pierre as the result of this particular 'making over' or renewal of the crust of the earth which is daily being wasted by denudation and by the never ceasing effects of heat and cold. According to Professor Judd, F.R.S., Professor of Geology in the Royal School of Mines, the subterranean energies, with their consequent outbursts, 'are necessary to the continued existence of our globe as a place fitted for the habitation of living

[1] The *sang froid* of the Governor of Martinique was evidently shared by the editor of *Les Colonies*. Two days before the fateful morning of May 8, that journal spoke very scornfully of the timid: 'All along Rue Victor Hugo people were at their windows to-day, speaking with passers-by. Some said that the Rivière Roxaline was overflowing, and that the Dépres was also. Homeless people from the surrounding villages filled the streets all expressing the greatest anxiety. *We must confess, however, that we see no ground for alarm.* Early this morning we heard some one say at a window: "It is impossible for us to sleep, yet Pelée is snoring loudly."'

In the issue of May 7, the very last number of the paper, this appeared: 'Many continue to flee by day and by night, carrying their baggage and children with them. The steamers are full. There are more than the usual number of foolish, frenzied, people on the Fort de France line. Since May 5 there has been an average of eighty passengers per day, but yesterday 300 took passage for Fort de France. We confess that we cannot understand the cause for this exodus from St. Pierre. It seems to us this city would be much safer in case of an earthquake. In any event, it is a better place than Fort de France.'

beings.'[1] He further holds 'that the mischievous and destructive effects of these energies bear but a small and insignificant proportion to the beneficial results with which they must be credited,' and proceeds to remark:[2]—

'The waters condensing from the atmosphere and falling upon the land in the form of rain, snow, or hail, are charged with small quantities of dissolved gases, and these waters penetrating among the rock-masses of which the earth's crust is composed, give rise to various chemical actions of which we have already noticed such remarkable illustrations in studying the ancient volcanic products of our globe. By this action the hardest and most solid rock-masses are reduced to a state of complete disintegration, certain of their ingredients undergoing decomposition, and the cementing materials which hold their particles together being removed in a state of solution. In the higher regions of the atmosphere this work of rock-disintegration proceeds with the greatest rapidity; for there the chemical action is reinforced by the powerful mechanical action of freezing water. On high mountain-peaks the work of breaking up rock-masses goes on at the most rapid rate, and every craggy pinnacle is swathed by the heaps of fragments which have fallen from it. The Alpine traveller justly dreads the continual fusillade of falling rock-fragments which is kept up by the ever-active power of the frost in these higher regions of the atmosphere; and fears lest the vibrations of his footsteps should loosen from their position of precarious rest the rapidly accumulating piles of detritus. No mountain-peak attains to any very great elevation above the earth's surface, for the higher we rise in the atmosphere the greater is the range of temperature and the more destructive are the effects of the atmospheric water . . .'

'The disintegrated materials, produced by chemical and mechanical action of the atmospheric waters upon rock-masses, are by floods, rivers and glaciers, gradually transported from higher to lower levels, and sooner or later every fragment, when it has once been separated from a mountain-top, must

[1] *Volcanoes: What They Are and What They Teach*, page 282. International Scientific Series. Kegan Paul, Trench, Trübner & Co., 1893.

[2] *Ibid.* pp. 283, 284, 285.

reach the ocean, where these materials are accumulated and arranged to form new rocks.

'Over every part of the earth's surface these three grand operations of the disintegration of old rock-masses, the transport of the materials so produced to lower levels, and the accumulation of these materials to form new rocks, is continually going on. It is by the varied action of these denuding agents upon rocks of unequal hardness, occupying different positions in relation to one another, that all the external features of hills, and plains, and mountains, owe their origin.

'It is a fact, which is capable of mathematical demonstration, that by the action of these denuding forces the surface of all the lands of the globe is being gradually but surely lowered; and this takes place at such a rate that in a few millions of years the whole of the existing continents must be washed away and their materials distributed over the beds of the oceans.

'It is evident that there exists some agency by which this levelling action of the denuding forces of the globe is compensated; and a little consideration will show that such compensating agency is found in the subterranean forces ever at work within the earth's crust. The effects of these subterranean forces which most powerfully arrest our attention are volcanic outbursts and earthquake shocks, but a careful study of the subject proves that these are by no means the most important of the results of the action of such forces. Exact observation has proved that almost every part of the earth's surface is either rising or falling, and the striking and destructive phenomena of volcanoes and earthquakes probably bear only the same relation to those grand and useful actions of the subterranean forces, which floods do to the system of circulating waters, and hurricanes to the system of moving air currents.'

With these conclusions there cannot fail to be general agreement; volcanic eruptions must be regarded as among the beneficial aspects of that interplay of natural forces which has made the world habitable by human beings and without which neither civilization nor progress would be possible.

Three things have been set forth in these preliminary observations:—

1. Generally prevailing ignorance as to the final cause, among many contributory causes, of earthquakes and volcanic eruptions,—an ignorance which, it is declared by the present writer, in view of the discoveries of, and their application by, Mr. Hugh Clements, has now no excuse for continuance, and, should it again be displayed, ought to become punishable by the State.

2. That Nature, when about to manifest herself, whether by earthquake or volcanic output, or cyclonic outburst, gives full notice of her intentions and allows ample time for human adjustments; and

3. That these phenomena are not wholly unbeneficial to humanity at large, and should be studied in the light of the ample warnings given, so that good to mankind and not evil may be the consequence.

Incidentally it has been stated that the meteorological phenomena of the world in which we live are capable of like accurate forecast, accurate because Nature's laws in operation, with the recorded results, are alone taken as the basis of prediction.

The 'cloud-bursts' of the middle West States of the American Union,

the cyclones of the Bay of Bengal and the storms of the Arabian Ocean,

the typhoons of the China Seas,

the terrible gales of the 'Cape of Storms' and of the south-east coast of Africa,

the tornadoes of the West Indies, alike with

the milder aspects of seasonal changes in tropical and temperate zones,

the gentle rainfall,

the circling winds,

the range of temperature,

are, in each and every instance, predictable with such

certainty that the agriculturist may labour with as sure a knowledge of the weather before him as the pilot on every shore has trustworthy information as to the lift and drop of the tidal waters he navigates. The laws which govern two of the great phenomena of animated and non-animated nature, the tides of the ocean and the tides of the air, are identical. The burden of this book is to show the adaptation to meteorological conditions of natural forces; the effects of these forces in other directions are now among the axioms of science and observation, and are never subject to doubt or to cavil.

APPENDICES

I. Professor Shaler's Conclusions

Mr. R. N. S. Shaler, Professor of Geology, Harvard University, with great courage descended into a portion of the crater of Mont Pelée before the outbursts had finally ceased. What he there saw does not call for quotation here, but his conclusions may be submitted to the reader. In the *North American Review* for July Professor Shaler describes his adventurous journey, and concludes thus :—

'While the accident appears to have been in a geological sense relatively unimportant, the position of the town in relation to the cone, the neighbourhood of sea which barred flight, and the somewhat unusual swiftness in the development of the outbreak, combined to make it a very great calamity.

'There are certain lessons to be drawn from the disasters of Martinique and St. Vincent. The first of these is that the neighbourhood of a volcano that has so recently been in eruption as to retain its shape in a well preserved state, is not a fit place for a city or other important seat of man's endeavours. The second concerns the importance of systematic and extended observations of volcanoes, with a view to an effective foretelling of approaching eruptions. So far observations of this nature have been limited and imperfect. There is reason to believe that it will neither be difficult nor costly to obtain data such as would have spared the thousands who died in the recent disasters. It is clearly not in the power of man to prevent the activity of volcanoes, as he well may the vastly more destructive plagues of war and disease; but he may, by his understanding, lessen the evils they inflict, as he does those of the hurricane or the earthquake. It is well to note, however, that the calamities which may thus be avoided, though in their nature appalling,

constitute but an insignificant part of the sum of death and destruction that comes to man. Though this earth beneath our feet is the seat of titanic forces, it deals gently with its living tenants,—far more gently than they with one another. That life is here as the result of at least a hundred million years of uninterrupted progress, shows that the interference of the powers of the under-earth with the course of life has not been serious.'

II. Mr. Robert Hill's Theories

Mr. Robert T. Hill, of the United States Geological Survey, who visited Mont Pelée after the first eruption, in his record of what he learned in Martinique, considered the access of water theory to molten lava, and dismissed the theory as not proven. He sets out instead two others, viz. :—

'1. The heat-blast theory. This assumes that the lapili gases and steam of the cloud were ejected with sufficient initial force to destroy buildings from two to five miles distant, and were sufficiently hot to inflame the city and destroy the people by singeing, suffocation, and asphyxiation.

'2. The aerial gas explosion theory. This postulates that the weight of the cloud, causing it to descend, the exhaustion of air, the flame, and the great aerial force developed, were the products of an explosion caused by the union of the gases of the cloud with the oxygen of the air, which took place in the air, but near the surface of the ground.'

He seems to favour the second idea, which is backed by the circumstance that combustible gases were undoubtedly present in the eruption. For weeks the city had filled with sulphurous gases, so strong that horses dropped dead in the streets. The captain of the French cruiser *Suchet* after the eruption picked up pieces of pure sulphur in the streets of St. Pierre. Professor Hill him-

self witnessed a later and minor eruption of Pelée, when a blinding flash of light, followed by a shower of incandescent pumice and a discharge of balls of fire, showed him what volcanoes can do.

CHAPTER I

The World 'All of a Tremble' now as in the Distant Past—Continuity and Similarity of Action the Dominant Feature in Physical Phenomena

'The Earth Waste and Void': the Birth of the Moon.
Sir Robert Ball and Professor G. H. Darwin's Arguments.
Secular Changes in Earth require 54,000,000 Years for Accomplishment.
Changes 'must be going on' at Present Time.
Chief Earthquakes in Nine Months of 1900–1901.
Insistence of Fact of Continuity of Action and Identity in Process.
The Moon's Striking Evidence of the Action of Volcanic Forces.
Professor Judd and Richard A. Proctor on the Moon's Volcanoes.
The Measure of the Earth's 'Pull' on the Moon.
Oil Wells near Gulf of Mexico Susceptible to Lunar Tidal Pull.
The Moon's Tide and Generating Force Illustrated by Professor Darwin.
'. . . Aggregate Wave . . . must travel One Thousand Miles an hour to keep up with the Moon.'
Cramping Influence Observable in Meteorological Studies.
Weather Prediction a Byword and a Scorn.
The Tenuity of the Atmosphere Compared with the Tenuity of a Comet.
Dr. Todd's Graphic Illustration of Cometary Substance.
The Break-up of Cometary Systems.
The Westward Movement of the Daily Barometric Wave One Thousand Miles an hour.
Mysteries Cleared up by Mr. Clements' Discovery.
Great Value of Meteorological Records of the Past.
The Atmosphere not an Imponderable Substance: its Weight many Billions of Tons.
Mass of the Atmosphere 1,200,000th part of Earth.
The Extent of the Moon's Attractive Power on the Atmosphere more than four and a half times greater than on the Oceans.

Helmholtz' Theory of Atmospheric Waves with Professor Darwin's Comments thereon.
Geikie on the Atmosphere's Part in the Making of the Earth.
Mr. Clements' Propositions as to Effect of Moon on the Earth's Atmosphere.
Maximum Disturbing Force of Sun and Moon Exerted at an Angle of 45°.
Gradual and Orderly Manner in which Meteorological Phenomena are Developed.

'There rolls the deep where grew the tree;
O earth, what changes hast thou seen!
There, where the loud street roars, hath been
The stillness of the central sea.

'The hills are shadows and they flow
From form to form, and nothing stands;
Like mists they melt; the solid lands,
Like clouds they shape themselves and go.'
—TENNYSON.

'Here there is a vast system of circulation, ceaselessly renewed. And in the system there is not a drop of water which is not busy with its allotted task of changing the face of the earth. . . . Day by day the process is advancing. *So far as we can tell it has never ceased since the first shower of rain fell upon the earth.*'—SIR A. GEIKIE, art. 'Geology,' *Encyc. Brit.*, ninth edition, p. 267.

'The fall of half an inch in the barometer is equal to the removal of a mass of atmosphere previously pressing with a weight of 36 lbs. on every square foot of surface, and when this is removed over a large area the total weight lifted is enormous. Thus a fall of one inch in the barometer represents the removal of a pressure of more than a million tons from every square mile by land or sea, and it is only natural that the shifting of such a load should be followed by marked changes in the weather.'

'THE earth was waste and void.'[1] The planet on which we live could be thus accurately described during a vast period of its long existence. That portion of the period I have in my mind's eye at the moment of writing is some considerable time subsequent to the day on which our Mother Earth gave birth to the moon. The birth of Minerva, fully equipped with the

[1] Gen. i. 1., Revised Version.

advantages of maturity from the brain of Jove, was but a latter-day fable, the foundation of which probably is connected with the occurrence whereby the earth's satellite started full-orbed on its independent career. The moon was independent from its moment of birth, however, only so far as actual contact is concerned; in all other respects the orbs were mutually dependent, bound one to the other with stronger cords than steel could furnish. 'It is now known,' says Sir Robert Ball, 'mainly by the researches of Professor G. H. Darwin that, in all probability, the moon was originally a part of the earth, and that a partition having occurred while the materials of the earth and moon were still in a plastic state, a small portion broke away to form the moon, leaving behind the greater mass to form the earth. Then, under the influence of the tides, which may agitate a mass of molten rock, as the moon was once, just as they may agitate an ocean, the moon was forced away, and was ultimately conducted to its present orbit.' Professor Darwin's own words are as follow :—

'We begin with a planet not very much more than eight thousand miles in diameter, and probably partly solid, partly fluid, and partly gaseous. It is rotating about an axis inclined at about 11° or 12° to the normal of the ecliptic with a period from two to four hours, and is revolving about the sun with a period not much shorter than our present year. The rapidity of the planet's rotation causes so great a compression of its figure that it cannot continue to exist in an ellipsoidal form with stability, or else it is so nearly unstable that complete instability is induced by the solar tides. The planet then separates into two masses, the larger being the earth and the smaller the moon. It is not attempted to define the mode of separation, or to say whether the moon was initially a chain of meteorites. At any rate it must be assumed that the smaller mass became more or less conglomerated and finally fused into a spheroid, perhaps in consequence of impacts between its constituent meteorites, which were once part of the primeval planet. Up to this point the history

is largely speculative, for the conditions of instability of a rotating mass of fluid have not yet been fully investigated. 'We now have the earth and moon nearly in contact with one another, and rotating nearly as though they were parts of one rigid body. This is the system which was the subject of dynamical investigation. As the two masses are not rigid, the attraction of each distorts the other, and, if they do not move rigorously with the same periodic time, each raises a tide in the other. Also the sun raises tides in both. . . .'

'At some stage the earth became more rigid, and oceans were formed so that oceanic friction probably came to play a more important part than bodily tidal friction. If this be the case, the eccentricity of the orbit, after passing through a stationary phase, begins to increase again. We have now traced the system in which the day and month are increasing but at unequal rates, the inclination of the lunar proper plane to the ecliptic and of the orbit to the proper plane are diminishing, the inclination of the terrestrial proper plane to the ecliptic is increasing and of the equator to its proper plane is diminishing and the eccentricity of the orbit is increasing. No new phase now supervenes, and at length we have the system in its present configuration. The minimum time in which the changes from first to last can have taken place is 54,000,000 years. . . .

'Thus changes of the kind here discussed must be going on, and must have gone on in the past. And for this history of the earth and moon to be true throughout, it is only necessary to postulate a sufficient lapse of time, and that there is not enough matter diffused through space to materially resist the motions of the moon and earth in perhaps 200,000,000 years. It seems hardly too much to say that, granting these two postulates, and the existence of a primeval planet, such as that above described, a system would be necessarily developed which would bear a strong resemblance to our own. A theory, reposing on *veræ causæ*, which brings into quantitative correlation the lengths of the present day and month, the obliquity of the ecliptic, and the inclination and eccentricity of the lunar orbit should have claims to acceptance.' [1]

[1] *Encyc. Brit.*, Ninth Edition, vol. xxiii., art. 'Tides,' pp. 378, 379.

'Thus changes of the kind here discussed must be going on,[1] and must have gone on in the past.' '*Must be going on.*' That is to say, precisely the same phenomena of mutual attraction between earth and moon, with the sun as a contributory, are occurring to-day, exactly as they

[1] The many earthquakes and volcanic eruptions which have taken place during 1902 will secure for this observation general assent even amongst the least heedful of mankind. But, even to those who take small measure of passing phenomena, a reference to the many earthquakes and eruptions which occurred in the last three months of 1900 and the first six months of 1901, and the following recital of the chief of these phenomena may be surprising in the emphasis they give to Professor Darwin's observations :—

'On Monday, October 29, 1900, Caracas and the surrounding district in Venezuela were visited by a violent earthquake which caused considerable damage to property. The British and German Legations were seriously damaged, but the Ministers and English Colony escaped. The town of Guarenas was entirely destroyed, twenty-five persons lost their lives amid the falling debris, while a large number were seriously injured. On January 22, 1901, a slight earthquake shock was felt in England in the district of Wrexham. In the neighbourhood of Ruabon and Rhosllanerchrugog the vibration lasted several seconds. On February 16, at 9 p.m., an earthquake shock of some violence was recorded at Trieste Observatory in Austria. The direction of the seismic disturbance was towards N.N.W. According to advices from Laibach an earthquake shock was also felt there on the same date, but no damage was done. On March 31 the instruments at the observatories of Rome, Padua, Catania, and Florence recorded seismic movements of some violence. On the same date a slight shock of earthquake was experienced at Benevento. At Odessa a smart shock lasting nearly a minute was felt soon after 9 a.m. The lighthouse at Cape Kalikra, on the European coast of the Black Sea, was destroyed by an earthquake. On April 2, at Szoreg, a house fell in. At Semlin and Obecse a series of vibrations occurred at about 6 p.m., lasting from two to six seconds, and with a motion directed from east to west. On April 24 a slight earthquake was experienced at Rome; it did a good deal of damage to the Raphael Loggia at the Vatican and to the Pantheon. On the previous day (April 23) several shocks had been recorded at Guernsey, but no material damage resulted. On May 11 a very strong earthquake shock visited Nicelosi, Sicily, but though several houses sustained damage, no one was injured. On May 21 a shock was felt at Florence. On May 23 advices received

have occurred through unthinkable millions of years, differing not in essence but in effect.

This fact of continuity of action and identity in process through a long distant past to the present day may suffer a little insistence. Its importance to the argument these pages are designed to advance cannot be over-rated. From the outer circumference of the amorphous mass of widely distributed vaporous matter now become consolidated into the partly solid centre of the solar system our earth was whirled, itself then but an attenuated conglomeration of vapour. The earth had this origin in common with the other planets of the solar system. In its turn the earth assumed the responsibility of parentage. Whether deliverance occurred as the consequence of the sun's attraction exerted at an angle whereby its force would for a brief space be at an insupportable maximum upon such easily affected matter as then existed in our globe, or whether it was a result of active forces in the

from Java announced that the volcano of Koloct in the Kediri district had been in eruption and that the stream of lava had taken the direction of Blitar. The devastation it produced recalled the disaster of Pompeii. The inhabitants of the district fled in terror, and a large number of natives and whites who resided on the slopes of the crater lost their lives. Ninety plantations on the borders of the Kediri and Semarang settlements were devastated, while a large tract of Eastern Java was buried in mud and ashes. The volcano had been quiescent since 1875. On May 22 a telegram from Basle stated that an earthquake shock had been experienced there at eight o'clock, shaking the houses perceptibly, and moving from north to south. On June 11, at 3 a.m., a strong shock of earthquake was felt at Caracas, Venezuela, the scene of the disaster on October 29, 1900. On July 9 two distinct, though slight, shocks of earthquake were noticed in the afternoon in the Lake district. At Ambleside a rumbling noise was heard like distant thunder, and vibrations of the earth, causing crockery to rattle, were very apparent and alarmed some of the inhabitants. On July 14 an earthquake occurred in the region of Nyon and Geneva. It was accompanied by considerable noise and created a panic at Nyon, at which place many of the buildings received a severe shaking.'—*Whitaker's Almanack*, 1902.

still glowing mass which caused a diurnal rotation from two to four hours and so compelled the rotating mass to throw off a loosely-held portion of the outer envelope, Professor Darwin tells us cannot be ascertained. Probably, as is the case to-day with earthquakes and volcanic eruptions, the separation was a resultant of these two forces in combined action and of other forces which cannot now be estimated. Separation, by whatsoever means accomplished, did not, it may be repeated, mean the cessation of all connexion between parent and child, between the producer and the product. On the contrary, an intimate relation was at once established which has profoundly affected the shape and daily experience of both. Each has acted and reacted on the other. The earth's influence on the moon has been vastly greater than the moon's influence on the earth.[1] The vast system

[1] Incidentally, these contentions are illustrated and confirmed by Professor Judd, at p. 367 of his work on *Volcanoes* (International Scientific Series) where he says: 'The moon, which is of far smaller size than our earth, exhibits on its surface sufficiently striking evidences of the action of volcanic forces. Indeed, the dimensions of the craters and fissures which cover the whole visible lunar surface are such that we cannot but infer volcanic activity to have been far more violent on the moon than it is at the present day upon the earth. This greater violence of the volcanic forces of the moon is perhaps accounted for by the fact that the force of gravity on the surface of the moon is only one-sixth of that at the surface of the earth, and thus the eruptive energy will have a much less smaller resistance to overcome in bursting asunder the solid crust and accumulated heaps of ejected materials on its surface. But the volcanic action on the moon appears now to have wholly ceased, and the absence of both water and atmosphere in our satellite suggests that this extinction of volcanic energy may have been caused by the complete absorption of its gaseous envelope.' Proctor, in his *Old and New Astronomy* (Longmans, Green and Co.), p. 519, argues to the contrary. 'Craters as large as the moon,' by which I suppose is meant 'as large as those in the moon,' says Proctor, 'were not wanting on the earth in long past times.' He also says: 'It would be a mistake to suppose that no such craters were ever formed on the earth. The subterranean forces have

of volcanic mountains, and especially the enormously great dimensions of individual craters, are, I submit, an indication of the tremendous 'pull' which the earth exercised on the moon in its more plastic days, a 'pull' which probably has largely helped to our satellite's speedy decay and decrepitude while the world itself is still in a comparatively early stage of development. There has been all the difference imaginable between the result of the reciprocal influence which parent and child have exerted one on the other. The parent's influence was radiated forth with a violence which, it would seem, must have rendered life, as we understand it, at any time an impossibility on the surface of the moon. Sentient existence, according to our comprehension, would be incompatible with the measure of force continually exerted by the earth on its satellite, force which never left the surface of the latter in a state of rest until all its internal heat had radiated into space, and, for aught that is positively known, may not have ceased even then. On the other hand, the moon's influence upon the earth has been wholly beneficial. To the moon, aided to a minor extent by the sun, our world owes its mountain ranges and its deep ravines, its hills and its valleys, its contours and its level

indeed to work against the six-fold greater energy with which terrestrial gravity, as compared with lunar gravity, holds down the materials of the crust ; but the self-same excess of gravitating energy gives to the earth's subterranean forces correspondingly greater strength. For all the vulcanian energies of a planet are directly or indirectly the product of the energy of gravity possessed by the planet's mass.' This, no doubt, is correct so far as it goes. But we now know that inherent force is not alone accountable for vulcanity. The 'pull' of the associate orb from the outside does more than the explosive power from within. More than that : the outward 'pull' makes possible, by relief of pressure, explosion from the inside. Consequently the effect of the earth's pull upon the moon, once a crust had formed on our satellite, must have resulted in the formation of vastly greater lacunæ in the crust of the moon than the moon could occasion in the crust of the earth.

surfaces, its storms and its winds, its rains and its dews. Every day and night, all day and all night, from its birth, when slowly solidifying glowing vapours and plastic matter were tending to the present state of chill inertness, the moon has enabled its parent to become an abode fit for human habitation by coercing it through stern processes which made animal and vegetable life possible. To-day, as in aeons of ages ago, the moon is the most potent factor in controlling the earth's atmosphere, keeping in motion currents of the air, lifting and letting down the waters of the ocean and thereby causing tides to rise and fall. More than that, it affects the surface of the earth itself and the liquids buried in that surface. In the oil-wells contiguous to the Gulf of Mexico the influence of the moon is declared to be as surely felt as it is by the waters of the Gulf itself. A number of wells, after being 'dead' for a month, during July 1902, quite unexpectedly 'spouted.' To one man this was not a matter of astonishment. Captain George A. Hill, of the Spindle Top Wells, had already observed that the supply of oil synchronized with some of the high tides in the Gulf.

'My assistant,' said Captain Hill, 'has called my attention to this matter before, but, like you, I was inclined to laugh, and did laugh at him. But he has been watching it for six months and declares, and I am now convinced, that when there is a heavy south-east wind and the tides on the Gulf are running unusually high, there is a very perceptible difference in the action of wells on Spindle Top. Of course these high tides always come along about the same time of the month as affected by the moon's position and the winds, and it is always about this time that the wells on the hill seem to improve. Of course in many instances the improvement is not sufficient to make them all spouters again, but even the pumping wells seem to do better, and those wells which at other times of the month seem to be indifferent producers become fine wells.' [1]

[1] Communication from Beaumont, Texas, dated July 21, 1902, in the *Galveston Daily News*.

The earlier strata of the earth show what the moon did by the exercise of its attractive influence in ancient times. What is it doing to-day? Its lifting force on our oceans may be estimated from the striking example which Professor Darwin employs. 'We may,' he says, 'conceive the moon's tide and generating force as making a wave in the canal,[1] and continually outstripping the wave it generates, for the moon travels along the equator at about one thousand miles an hour and the sea is less than thirteen miles deep. The resultant oscillation of the ocean must, therefore, be the summation of a series of partial waves generated at each instant by the moon and always falling behind her, and the aggregate wave, being the same at each instant, must travel one thousand miles an hour to keep up with the moon.'[2] But, I need not labour this point. Every one is agreed that the moon does exert enormous attractive force upon the waters of the earth. That these waters do rise and fall twice diurnally can be verified by the senses. The influence of the moon upon the greater ocean, the ocean of the atmosphere, which extends forty to fifty miles from the earth's surface[3] outwards towards surrounding space, cannot be seen with the eye, and, so far, has not been intelligently measured and handled by instruments of man's devising which would describe what the eye is incapable of ever beholding. To the majority of men and women what the

[1] In the preceding sentences of the article from which I quote, Professor Darwin says: 'Suppose that the ocean consisted of a canal round the equator, and that an earthquake or any other cause were to generate a great wave in the canal, this wave would travel along it with a velocity dependent on the depth. If the canal were about thirteen miles deep, the velocity of the wave would be about 1,000 miles an hour, and with a depth about equal to the depth of our seas the velocity of the wave would be about half as great.'

[2] *Encyc. Brit.*, Ninth Edition, vol. xxiii. art. 'Tides,' p. 354.

[3] *Encyc. Brit.*, Ninth Edition, vol. x., art. 'Geology,' by Sir Archibald Geikie, F.R.S., p. 220.

eye does not see, or what other senses do not palpably recognize by sensation, does not exist. We do not see with the bodily eye the moon exercising influence upon the atmosphere: therefore, to our comprehension, the moon does not influence the atmosphere. We do, indeed, feel the consequences of an influence of some kind or other in the air we breathe and in the gaseous ocean in which we live. We are content to ascribe that of which we become aware in vague talk of the Atlantic Ocean area being a developer of storms which find their way to England or to the United States, according to circumstances of which we know little or nothing. Or, a region of high pressure is announced, by a distant observer, with a trend of wind towards England, and the Meteorological Department tells us that an anti-cyclonic condition will set in above our heads and around us, and during its continuance calm weather will be our portion. What may be at the back of these manifestations seems, to the observer, to be of slight concern, or even of no concern at all, even though in the strictly cognate conditions of the tides of the ocean he is not satisfied until he can explain the part played in their production by moon and sun and the respective proportions of force exercised by each of these bodies. That is why weather prediction has to-day become a by-word and a scorn, a thing for contemptuous comment. Men will not get at the back of the north wind and of every other wind, will not find their way behind all meteorological phenomena to discern what are the controlling influences to which each phenomenon is subject. The professional meteorologists, sad to say, seem the least inclined amid many brethren to do more than act as did certain men in distant times to whom, when they asked for a sign from heaven, it was said: 'When it is evening, ye say, It will be fair weather, for the heaven is red. And in the morning, It will be foul weather to-day, for the heaven is red and lowering. Ye know how to

discern the face of the heaven; but ye cannot discern'[1]—what is behind these signs, though they are to be found by those who seek for them.

Perhaps the general reader may be assisted in his understanding of the great influence exerted by the moon in certain circumstances upon the atmosphere by a consideration of the influence exerted upon cometary matter not only by the sun but by the planets within the radius of whose influence such matter may come. The density of air at standard pressure and temperature, water unity, is as 1 to 770. Thus regarded atmospheric air might seem too flimsy to possibly become the subject of the moon's direct influence. But, to the tenuity of cometary matter the earth's atmosphere must seem almost a solid mass. 'On those rare occasions when stars have been observed through the tail of a comet, although it may be millions of miles in thickness, still no diminution of the star's lustre has been perceived. Even through the denser coma the light of a star passes undimmed, though the star's image, if very near the comet's nucleus, may be rendered somewhat indistinct. The air-pump is often used to produce an approach to a perfect vacuum; but in a cubic yard of such vacuum there would be many hundred times the amount of matter in a cubic yard of a comet's head.'[2] Collision with a comet 'would be much like an encounter with a shadow. Comets' tails are excessively airy and thin, or, as Sir John Herschel remarks, possibly only an affair of pounds or even ounces.'[3]

Yet, bodies of almost inconceivable tenuity to human observation as are comets, they are subject to every attractive influence within the orbit in which they move.

[1] Matt. xvi. 3.

[2] *A New Astronomy*, by David P. Todd, M.A., Ph.D., Professor of Astronomy and Director of the Observatory, Amherst College, U.S.A. Sampson Low, Marston, and Co., pp. 408, 409.

[3] *Ibid.* p. 409.

They are not too diaphanous to be outside the influence of the moons of Jupiter, while they seem ready to break up into separate organisms on the slightest provocation. They even divide into diverse bodies under the astronomer's direct observation. Disintegration takes place on almost every return to perihelion ; 'for example, the lost Biela's comet in 1846, the great comet of 1882, and Brooks's comet of 1889, the heads of which were seen to divide or to be divided into fragments . . . the comets of 1843, 1880, 1882, and 1887, travel tandem, and originally were probably one huge comet.' [1]

These changes are the consequence of attraction ; no internal force exists which, exerting itself upon the mass, could make the tenuous comet more attenuated. Attraction, or repulsion, always from the outside, does everything. In like manner, were it possible for the astronomer and the meteorologist to observe the play of forces upon and in the earth's atmosphere in the same manner that they study a comet's movements, probably there would never be a moment's hesitation as to the part played by moon and sun—by the moon particularly—in the causation of terrestrial phenomena.

Evidence in support of the extreme susceptibility of the atmosphere, and the vast changes which take place in it, is afforded in a paper read at the Second Convention of United States Weather Bureau Officials held at Milwaukee, Wisconsin, in August 1901. Its title was *The Westward Movement of the Daily Barometric Wave*, and was by Oliver L. Fassig, Ph.D., of Baltimore, Maryland. Twenty-four charts indicate its passage hour by hour round the world. Mr. Willis L. Moore, Chief of the Weather Bureau, described the wave as 'starting at 1 a.m. on the west coast of Europe; at 2 a.m. the barometric wave is in the centre of the Atlantic Ocean, and by 6 o'clock it is passing off our western coast into the

[1] *Ibid.* p. 411.

Pacific Ocean.' Attention was called to the extreme rapidity of the movement, 'whether we consider the earth as moving under the wave or the wave as moving over the earth. It is moving a thousand miles an hour in the equatorial region. Our ordinary storms move only thirty to forty miles an hour, but this little diurnal cyclone is moving a thousand miles an hour in the opposite direction to that of the ordinary storm. It has very much the same shape as the ordinary cyclones and anti-cyclones we have on the map, only it moves with a velocity many times as great.'[1]

The chief merit of Mr. Clements' discovery is that the exceeding many and complex changes in the position of the moon towards the earth clear up the mysteries of meteorological conditions. What aforetime was mysterious is now a brilliant example of cosmic law. Mr. Clements finds that the two planets and the sun, when in like juxtaposition with each other, invariably produce like phenomena in the atmosphere of the earth, and so give to us what we call 'weather.' He does not proceed to account for each phenomenon one by one, nor does he describe by any process of induction or deduction the exact consequence of each manifestation of luni-solar energy. These are beyond the power of man in the present state of meteorological science. All that, however, will come in due course as the new science is better understood. He does vastly better than this. The earth, daily, and hourly, and momently, itself furnishes a record of the result of the continually varying conjunctions of the three bodies.

'For ever changing as each moment flies,
Yet ever constant, earthly skies.'

Of the record which the earth makes, mankind takes a

[1] Page 65. *Proceedings of the Second Convention of Weather Bureau Officials*, Milwaukee, August 1901. Washington: Government Printing Office.

note;—that is to say, civilized man during the past century or two has, in a systematic way, begun to do this. He watches the barometer and the thermometer and transcribes the 'readings.' He measures the raindrops as they fall in gentle shower or in pelting storm. He observes the passing clouds, and tells the duration or absence of daily sunshine. He carefully regards all aberrations from the normal, and describes them in detail. An Association of such observers is formed, with or without State assistance, and the observations of each are collected and made available for all who may be interested.

Mr. Clements has found the three bodies—sun, moon, and earth—move in varying cycles towards each other, varying according to the limits of respective cycles, but all embraced within a definite period. With this knowledge in his possession he goes to the transcripts of the earth's own handwriting, which meteorologists have secured, ascertains the position of moon, sun, and earth towards each other on any given day, and, according as Nature's own record has been accurately or inaccurately described, he is able to tell us what a day one month hence, a day one year ahead, any day three years before us, what the weather of those days respectively will be. If the record to which he goes be not accurate, by the measure of its inaccuracy will be the inaccuracy of his prediction. If the record be absolutely accurate, so will his forecast be absolutely accurate. For detail and proof of all this the reader will have patience whilst the argument is being developed; in good time all will be explained, and many illustrative facts will be submitted. These, carefully laid down, a statement of the *modus operandi* of Mr. Clements' predictions, with the laws governing them, and with a multitude of results in proof, will await the reader's judgment. It is submitted that a course of procedure more scientific or more in accordance with a dependence solely upon observed facts, is not conceivable.

Because of its tenuity to the perception of the average man, who has become completely in accord with his environment, we are apt to think of the atmosphere surrounding us as representing an almost imponderable substance. It may surprise generally intelligent persons to learn that its weight lies between 5,000,000,000,000,000, and 5,400,000,000,000,000 tons,[1] and that men live, and move, and have their being, at the bottom of an ocean the weight of the constituents of which is an unrealisable quantity. In his article 'Atmosphere' in the ninth edition of the *Encyclopædia Britannica*, Alexander Buchan cites Sir John Herschel as calculating the total weight of an atmosphere averaging thirty inches of pressure at about eleven and three quarter trillions of pounds (lbs. 11,750,000,000,000,000,000); and adds that, making allowance for the space occupied by the land above the sea, the mass of such an atmosphere is about the 1,200,000th part of that of the earth itself.

Either set of figures represents a total bulk and weight of which no real conception can be formed. The totals are too vast for the mind of man to adequately grasp. But at least the statement suffices to enable us to understand that an enormous mass of material exists in our atmosphere which may become subject to the attractive influence or 'pull' of the moon in the first instance, of the sun in the second, of both bodies acting together in the third. Being of lighter texture than the water on the earth's crust it necessarily is more susceptible to outside attractive influence than are either water or earth particles. How greatly the moon's power is exerted on the waters of the globe has been shown on a previous page:[2] it must be conceded that our ever-faithful attendant's power over the air must be much greater than that exerted in con-

[1] *Old and New Astronomy*, Richard A. Proctor, p. 93. Longmans.

[2] See p. 42, *ante*.

nexion with the more solid substances which she, admittedly, controls as she will.

The bearing of this pregnant fact, that, in influencing the earth's atmosphere, as compared with influencing the earth's crust and the waters on (and in) the earth, the moon is manipulating not the whole earth, or all the oceans, but only 1,200,000th part of the earth's mass, seems to have escaped direct observation. Allusively, however, it is now and again recognized in astronomical research, and by no one so plainly and so fully as by Professor Darwin, though, singularly, he refrains from drawing what, to the present writer, seems the obvious conclusion. In commenting upon wave-length by analogy he quotes Helmholtz, and, in a profoundly interesting argument, he speaks of air-waves of twenty miles in length as corresponding with water-waves of ten yards in length.[1] Regarded in the light of preceding illustrations and arguments in this chapter this statement by Professor Darwin would indicate that the effect of the moon's attractive influence on the atmosphere is more than four and a half times greater than it is on the oceans. If it were in the same ratio the water-wave length of ten yards would find its correspondence in an atmospheric wave of less than five miles in length. The difference signifies the greater susceptibility of the atmosphere to the outward 'pull,' which, when moon and sun occupy a particular relation to the earth and to each other becomes immensely great, and terrifying phenomena necessarily follow. Were this contention dealt with by the author of *The Tides* in the same manner as the moon's influence on the waters of the globe is discussed by him, no doubt could remain as to the source of terrestrial phenomena. The whole passage in Professor Darwin's work runs thus :—

[1] *Tides and Kindred Phenomena in the Solar System*, by G. H. Darwin. John Murray, 1900. Pp. 45-47.

'Now Helmholtz has pointed out that one layer of fluid cannot slide over another, without generating waves at the surface of separation. We are familiar with this fact in the case of sea-waves generated by wind. A mackerel sky proves also the applicability to currents of air of Helmholtz's observation. In this case the moisture of the air is condensed into clouds at the crests of the waves and re-absorbed in the hollows, so that the clouds are arranged in a visible ripple-mark. A mackerel sky is not seen in stormy weather, for it affords proof of an upper layer of air sliding with only moderate velocity over a lower layer. The distance from crest to crest must be considerable as measured in yards, yet we must regard the mackerel sky as a mere ripple formed by a slow relative velocity of the two layers. If it is so it becomes of interest to consider what wave-lengths may be expected to arise when the upper current is moving over the lower with a speed of perhaps a hundred miles an hour. The problem is not directly soluble, for even in the case of sea-waves it is impossible to predict the wave-lengths. We know, however, that the duration of the wind and the size of the basin are material circumstances, and that in gales in the open ocean the waves attain a very definite magnitude.

'Although the problem involved is not a soluble one, yet Helmholtz has used the analogy of oceanic waves to an approximate determination of the sizes of the atmospheric ones. His method is not a very fertile one in many complex physical investigations, where an exact solution is not attainable. The method may be best illustrated by one or two simple cases.

'It is easy for the mathematician to prove that the period of a swing of a simple pendulum must vary as the square root of its length. The proof does not depend on the complete solution of the problem, so that even if it were insoluble he would still be sure of the correctness of his conclusion. If, then, a given pendulum is observed to swing in a certain period it is certain that a similar pendulum of four times the length will take twice as long to perform its oscillation. In the same way, the engine-power required for a ship is determinable from experiments on the resistance suffered by a small model when towed through the water. The correct conclusion is discovered in this case; although it is altogether impossible to discover the resistance of a ship by *a priori* reasoning.

'The wave-motion at the surface separating two fluids of different densities presents another problem of the same kind, and if the result is known in one case, it can confidently be predicted in another. Now oceanic waves generated by the wind afford the known case, and Helmholtz has thence determined by analogy the lengths of the atmospheric waves that must exist aloft. By making plausible suppositions as to the densities of the two layers of air, and as to their relative velocity he has shown that sea-waves of ten yards in length will correspond with air-waves of as much as twenty miles. A wave of this length would cover the whole sky, and might have a period of half an hour. It is clear then that mackerel sky will disappear in stormy weather, because we are too near to the crests and furrows to observe the orderly arrangement of the clouds.

'Although the waves are too long to be seen as such, yet the unsteadiness of the barometer in a gale of wind affords evidence of the correctness of this theory. In fact, when the crest of denser air is over the place of observation the barometer rises, and it falls as the hollow passes. The waves in the continual trace of the barometer have some tendency to regularity, and have periods of from ten minutes to half an hour. The analogy seems to be pretty close with the confused and turbulent sea, often seen in a gale of wind in the open ocean.'

The great part played in past times by the atmosphere in the making of the earth is well told by Geikie.[1] He points out that the air must, originally, have very greatly differed from its present conditions.

'The oxygen,' he remarks, 'which now forms fully a half of the outer crust of the earth was originally doubtless part of the atmosphere. So, too, the vast beds of coal found all over the world, in geological formations of many different ages, represent so much carbonic acid once present in the air. The chlorides in the sea likewise were probably carried down out of the atmosphere in the primitive condensation of the aqueous vapour. It has often been suggested that during the carboniferous period the atmosphere must have been

[1] *Encyc. Brit.*, Ninth Edition, vol. x., art. 'Geology,' pp. 220, 221.

warmer and with more aqueous vapour and carbonic acid in its composition than at the present day, to admit of so luxuriant a flora as that from which the coal seams were formed.'

Of various substances in the air in very minute quantities, such as gases, vapours, and solid particles, the same distinguished authority states :—

'The other substances in much more minute quantities are gases, vapours, and solid particles. Of these by much the most important is the vapour of water, which is always present, but in very variable amount according to the temperature, ranging from about four to a maximum of 16 grains in 1,000 grains of air.[1] It is this vapour which condenses into dew, rain, hail, and snow. In assuming a visible form, and descending through the atmosphere, it takes up a minute quantity of air, and of the different substances which the air may contain. Being caught by the rain and held in solution or suspension, these substances can be best examined by analysing rain-water. In this way ammonia, nitric, sulphurous and sulphuric acids, chlorides, various salts, solid carbon, inorganic dust, and organic matter have been detected.'

The so-called imponderable air being thus proved to be a very ponderable entity, and even subject to vast and varied influences, I may proceed to state Mr. Clements' propositions as to the effect of the moon on the earth's atmosphere in his own words :—

(1) In accordance with the law of gravitation the attraction of the moon on each and every particle of the atmosphere varies inversely as the square of the distance.

(2) Whether on the same or on the opposite side of the earth there is a large differential attraction between a particle of air and a particle of matter at the centre of the earth.

(3) The moon's horizontal disturbing force upon a particle

[1] 'The quantity of aqueous vapour depends upon the temperature, warm air being able to retain more than cold air. Air at the temperature of 10° C. is saturated when it contains 9·362 grammes of vapour in a cubic metre of air.'

of air above whose horizon the moon has risen varies directly as the sine of twice the moon's altitude; when the altitude is 45° the attraction is at a maximum, and from 0° to 45° the horizontal disturbing force increases from zero to a maximum, and from a maximum (at 45°) to zero (at 90°).

(4) When the moon's horizontal disturbing force acts upon a particle of air at rest the particle will move in the direction of the force with a gradually increasing velocity, the greatest velocity of the particle being attained when the force ceases to act.

(5) If the particle of air is moving in the opposite direction to that of the horizontal disturbing force when it begins to act the velocity of the particle will gradually lessen till it is brought to rest, after which the velocity will gradually increase in the direction in which the force acts.

(6) If the particle of air is moving at an obtuse angle to the direction of the horizontal force, the direction of the motion of the particle will be changed and the velocity of the particle will be lessened.

(7) If the angle is right the direction is altered without change of velocity.

(8) If the angle is acute the direction of the motion will be changed and the velocity of the particle will be diminished.

(9) A particle of air at rest will not begin to move until the horizontal disturbing force is sufficiently large to overcome friction, and when a gradually diminishing force just equals the force of friction it cannot increase the particle's velocity, but the particle will at that moment have attained its greatest velocity.

Now in order to show in what manner the air is acted upon by the moon's disturbing force we will take a few cases. We will suppose the moon to be on the equator, acting upon a particle of air at or near the equator. When the moon is on the horizon of the particle the particle will be moving in a south of west direction, and at an angle of 45°, when this maximum force acting with friction will bring the particle which was moving in a south of west direction to rest. The particle, still under the influence of the disturbing force pulling eastward, will begin moving to the east with a gradually increasing velocity, which will continue until the disturbing force becomes zero, when the moon reaches the particle's zenith; shortly before noon the disturbing force will have so

diminished as just to balance friction, and at this moment the air-particle will have attained its greatest easterly velocity. After the moon has passed the meridian the westerly force will begin to act; and increasing up to a maximum of 45°, and gradually decreasing to zero at 90°, will bring the particle to rest before moonset. After moonset an easterly force will begin to act, and increase to a maximum at an angle of 45°, and again bring the particle to rest some time before the moon's inferior transit, and the force continuing the air-particle will be pulled to the east with a gradually increasing velocity until the force becomes so small as just to balance friction, when the easterly velocity will be at a maximum about the time of the moon's inferior transit. Between the moon's inferior transit and moonrise the disturbing force acts similarly to that between the moon's transit and sunset.

With the moon still upon the equator, let us take an air-particle 10° north or south of the equator. The bearing of the moon at rising will be due east, one hour after rising the bearing will be about 87°, two hours after rising it will be 84°, three hours 80°, four hours 73°, five hours 57°, and six hours after rising the moon will be due south, and at 5, 4, 3, 2 and 1 hour before moonset the bearings will be respectively 57°, 73°, 80°, 84° and 87°. During the interval between one hour before the moon crosses the particle's meridian, and one hour after the moon's true bearing has changed 114°, while the moon's horizontal disturbing force passes through a minimum rate when she crosses the meridian. As before moonrise the air-particle will be moving a little south of west, and as some time after moonrise the bearing will be still nearly east the angle the horizontal disturbing force makes with the south of west direction of the particle before moonrise will be obtuse. The increased disturbing force as the angle diminishes will diminish the velocity of the particle and will cause it to move in a more southerly direction. The obtuse angle will diminish and pass through a right angle and become acute, and produce a high barometer some time before the moon transits the particle's meridian. The acute angle between the two directions will diminish till they coincide, the bearing of the moon continuing to change in the same direction but very rapidly as she approaches the meridian; an hour before the moon's meridian passage the true bearing changes rapidly and the angle between the bearing and the

direction of the particle's motion will increase rapidly from acute to right angle, and become obtuse some time after the moon's transit. The velocity of the air-particle will pass through a maximum and lower the air pressure as indicated by the barometer.

One hour after the moon's meridian passage the moon's bearing will be S. 57° W. from the particle, and afterwards the change in bearing will be slower and slower, while the rate of change in the direction of the particle's motion will gradually increase, and, as the rates of the changes of the two directions become equal, the obtuse angle between them no longer increases. The obtuse angle between the directions will diminish, pass through a right angle and become acute, giving a minimum velocity to the air-particle and a high barometer. On the disturbing force decreasing from an angle of 45°, from the air-particle, until moonset the acute angle continues and the velocity of the air-particle increases, reaches another maximum and low barometer. From moonset to moonrise the action upon the particle will be the same as from moonrise to moonset.

When the moon is on the equator and the air-particle is in latitude 45° N. or S., the bearings at 1, 2, 3, 4, and 5, before the moon's transit, and 5, 4, 3, 2 and 1 hours before moonset are respectively 21°, 39°, 55°, 68°, and 80°.

In this case the horizontal disturbing force of the moon will be at a maximum, when she crosses the meridian and gradually decreases towards moonrise and moonset. After moonrise the obtuse angle between the particle's direction and the moon's bearing will decrease gradually to a right angle, and after passing the right angle, the acute angle between the directions will gradually lessen until the directions coincide, after which the moon's true bearing crosses to the other side of the direction in which the air particle is moving, forming a gradually increasing acute angle, which diminishes again without attaining a right angle. The velocity of the air particle will increase till some short time before moonset, when there will be a lower air-pressure.

The moon's horizontal disturbing force upon an air-particle in a given latitude north when she is above the horizon is the same as upon a particle in the same latitude south, when she is below the horizon. The upper transit air-waves formed at any declination north, and the lower transit waves formed at

the same declination south, are equal. At places near the equator when the moon is moving north there will be four lunar air-waves, but the sizes and periods of the two upper transit waves will be larger than the two lower corresponding waves because the moon is longer above than below the horizon. At places further north in mid-latitudes there are only two air-waves the upper transit wave being the larger, the difference in size and periods of the air-waves increasing with the latitude, but at the same place the difference increases with the moon's declination.

Near the poles when the moon's declination is large the interior transit air-waves become insensible, leaving only the superior transit air-wave during the lunar day which gradually diminishes, and eventually disappears as the moon's declination increases, so that when the moon's declination is large there is no diurnal air-wave at all within the arctic regions. Besides the moon's horizontal disturbing force resolved perpendicularly to the meridian, there is also the moon's disturbing force parallel to the meridian. This force varies as the cube of the moon's horizontal parallax. This force is greatest when the moon is on the equator, and least when she is furthest from it for all places in the same latitudes, but, other circumstances being equal, it is greatest for places in latitude 45°, while at the equator and poles it is zero no matter what the moon's declination may be.

The waves formed by the moon's disturbing force are followed by a series of lesser waves of nearly equal period.

The sun produces disturbances of the air similar to those of the moon but much smaller, and the aerial waves and air-pressure are produced by the combination of the lunar and the solar waves.

The disturbing force of the sun, like that of the moon, gradually increases from the point, having the sun in its zenith or nadir from zero to an angular distance all round of 45° by a series of concentric circles, at which angle the disturbing force is at a maximum, and at the earth's surface, where the lunar and solar circles at this angle cut, the greatest disturbing force is produced. Other circumstances being equal, great storms like that at Galveston recently, or great earthquakes, are the result of such coincidences over any given place.

The effect of all this in producing the phenomena in the

atmosphere itself and on the earth's surface which we term 'weather,' will be found described in its proper place. (See Chap. VII, *inter alia*).

Probably the gradual and orderly manner in which the phenomena reveal themselves and actually work out has never been more exactly stated than in the monograph by Mr. Eliot, C.I.E., Meteorological Reporter to the Government of India, *Report on the Madras Cyclone of May*, 1877 (a cyclone witnessed by the present writer). It is true that Mr. Eliot had quite another theory in mind when in paragraph 137, p. 53, he said :—

'There is one point which it is necessary to bear in mind in the investigation of cyclones and cyclonic motion, and which has been somewhat neglected. It is that the generation, advance, and disintegration of the vast atmospheric disturbance which constitutes a cyclone is a very gradual process. It cannot be divided into parts, bearing no more relation than the larger divisions of a country like India do to each other. Demarcation into periods may be necessary in the investigation of a cyclone, but it is essential to keep fully in view the continuous character of the changes which occur. The only discontinuous element or factor is rainfall, which is always more or less intermittent in character. The dynamical principles involved in the motion of the atmosphere during a cyclone are similar to those which the motion of a railway train from station to station presents. There is, first of all, a gradual accumulation of kinetic energy, due to the fact that the resistance to motion is less than the moving force. During the second stage resistance on the average is equal to, and counterbalances the moving force, and there is no further accumulation of kinetic energy. In the third and last stage, the moving force gradually diminishes and vanishes, and the resistance to the motion becomes effective, and the kinetic energy of the moving mass diminishes, and, it may be, entirely disappears, being converted into the energy of heat by friction, or the potential energy of pressure.'

CHAPTER II

The Phenomena of Earthquakes and Volcanic Eruptions

Prevalent Theories on Earthquake and Volcanic Causation very Numerous.
Philosophers Look in the Wrong Direction for Causation.
The Theories Advanced Range from Reasonably Probable to Almost Impossible.
Destructive Eruptions Declared to be no Eruptions, but Meteor Impacts from Interspace.
Professor Bonney's Researches into Causes.
Unanimous Opinion among Volcanists that Percolation through Ocean Beds to Molten Strata Produces Steam, and Consequent Ejection of Molten Matter.
Causes Declared to be Inadequate:

Magnetic Currents, e.g. Tangential thrust on Earth's Crust.	Chemical Decomposition. Compression.

All Existing Theories Insufficient to Explain the Phenomena.
'A Physical Principle, yet Undiscovered,' Demanded.
Early Discovery of this Principle Predicted.
Professors Judd and Milne on Operating Causes.
Milne's Deliberate Turning-away from Clues Furnished by Atmospheric Movement.
Secondary and Consequential Incidents too much Regarded.
Mountain Chains Disprove the Eruptive Theory.
Seismic Frequency and Periodicity.
'Lunar Influence has to do with Earthquake Phenomena.'
Earth Tremors and a Low Barometer.
Earthquake Shocks in Japan and Accompanying Atmospheric Action.
Data in Scientific Works Unscientifically Described.

Appendix :

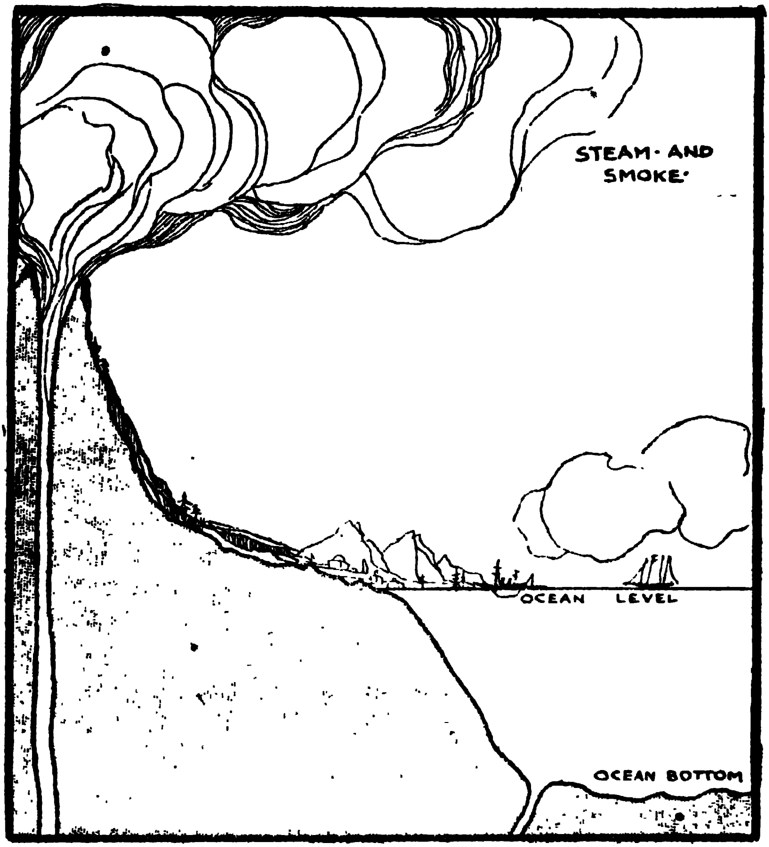
I. Curious Facts about Earthquakes and what Causes Them, by Walter George Hale.
II. *Nature* on the Meteoric Impact Theory.

> 'The earth has bubbles as the water has,
> And these are of them.'
>
> —*Macbeth*, act i., scene 3.

THE prevalent theories as to the causation of earthquakes and the occurrences of volcanic eruptions are as many as the proper modes of inditing tribal lays on the North Western frontier of India. Unlike the latter, however, all the theories are not right theories. Many of the operations of natural phenomena, which result in the manifestations described by such authorities as Geikie, Milne, Judd, Bonney, and Ball, are no doubt accurately described. At the best there is only inference to guide the observer. The reasoning is by inference or analogy only, but is not, on that account, untrustworthy. Indeed, inference and analogy must be employed so long as direct evidence is wanting. Evidence, however, once produced, there is no more need, as there is no more occasion, for either inference or analogy. Certainty is always to be preferred to possibility or even to probability. No direct observation of the internal state of the earth at any but very moderate depths is possible. The defect in one and all of the prevalent theories on volcanic eruptions and earthquakes is that, at the best, they are but partial explanations of the phenomena with which they deal, while every one of them fails to even take into account the possible prognostication of either volcanic eruption or shock of earthquake. To the present writer, as a student of the works of eminent seismologists, the reason for this negation is only too plainly apparent. The fault is not that Nature is unwilling to give the needed particulars, but that the philosophers are—almost, it would seem, of set purpose—turned away from the direction of her teaching. Not one of them looks upwards or around him or on the surface of the globe with a view to finding what he wants; every one endeavours to discover all the combining causes in the bowels of the earth. Each

of them, however, candidly admits that, when everything is allowed for which his theories or observations will permit, some further operating cause is wanting. That they might find this final and dominating cause of many associated causes in the moon's 'pull' when our satellite and our ruler together are at the greatest potential of each, never seems to occur, save in a very nebulous manner, to any student of seismology. Philosophers and others, learned in mathematical and physical lore though they be, share nevertheless the common fault of leaving the atmosphere out of consideration, apparently because the atmosphere itself is unseen and the operation of its influence is, in the present state of our knowledge, obscure.

It will help to a more thorough understanding of all that is involved in the accurate prediction of earthquakes and the outburst of volcanoes if the theories advanced to the present time are put on record. So far as they go, they range from the reasonably probable to the almost impossible. Foremost in the last category, if only for its singularity, must be placed the theory which, in effect, declares that the existing observations of volcanic eruptions is *maya*, or illusion, that the 'rain of fire' is a rain from outer space, the irruption into the earth's atmosphere and the impact upon the earth's surface of a stream of meteors, and that the volcano in eruption, or believed to be in eruption, is not the source of the calamitous conditions. The mountain supplies the music and space furnishes the destructive forces. Such, it is declared, is what happened in the earliest record of such phenomena, the destruction of Sodom and Gomorrah. The site where these cities stood, and the whole area of the Dead Sea and its environs are, it is declared, explainable only by a fall from outer space of solid masses which, by their impact, have driven that portion of the surface of the globe inwards—making, as



EJECTION OF STEAM AND SMOKE.
(*Prof.* GARRETT P. SERVISS.)

one has phrased it, a deep bruise on the earth's body. The latest exponent[1] of this theory is very positive. 'St. Pierre was destroyed,' he says, 'with little doubt, in the same manner that Sodom and Gomorrah were, and as fifty other towns have been destroyed during historical times.' In support of his contention this writer claims that no one but himself 'pretends to explain the origin of this phenomena,' and he adds, 'the general knowledge of the subject is remarkably limited.' He cites Mallet's *Catalogue of Earthquakes* and Boscowitz's *Earthquakes* as supporting his views. 'Fire,' he says, 'often rains out of the sky during earthquakes, and is seen in the form of meteors, by night; Mallet mentions meteors in connexion with hundreds of earthquakes, and he often courts such mention where the account states and repeats that there must be some relation between meteors and earthquakes, though it remained for the writer to find what this relation really is.'

The text need not further be burdened with Mr. Hale's observations. They are, he says, exclusively his own, and are likely to remain his own. When a complete explanation of phenomena is at hand, and when this explanation is also a study in causation resulting in definite proof that earthquakes and volcanic eruptions are as predictable as are eclipses and tides, everything outside of the sufficient evidence is, and may be treated as, unnecessary. There is, however, much of curious lore in the narrative before me. Its contentions, it may be remarked, are not so novel as Mr. Hale flatters himself they are, nor is he so original in his speculations as he supposes himself to be. So long ago as 1871 the present writer brought the theory, previously advanced in

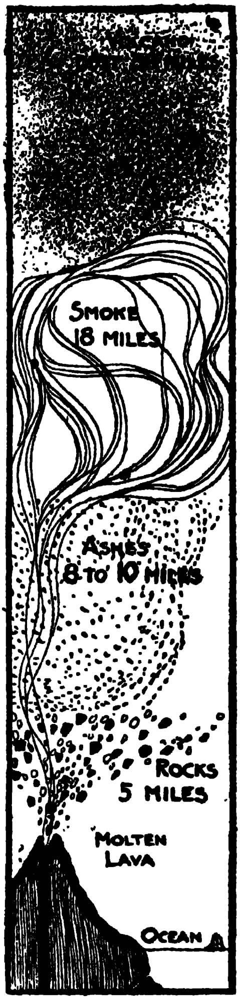
[1] George Walter Hale, art. 'Curious Facts about Earthquakes and What Causes Them,' *New York American and Journal*, May 18, 1902.

an interesting study published in *The Builder*,[1] under the attention of two of the most learned astronomers of the day, both of whom are still living. In view of this circumstance, and because of its intrinsic interest, the chief portion of Mr. Hale's article is given as an appendix to this chapter.

To turn, however, from what is fanciful to that which, to some extent, is established scientific fact, Professor Bonney, in Chapter VI of his recent work on Volcanoes,[2] describes an eruption as 'the discharge from underground, more or less explosively, of material which mostly is or has been in a molten condition.' He asks two questions :—

What produces the explosive phenomena ? and What has caused the material to be molten ?

The eruption is, obviously, due to 'some agent which is strengthened by repression' (p. 280). Steam[3] is declared to be 'the main explosive' (*ibid.*). 'Every explosion, every discharge of projectiles is accompanied by a jet of steam, like the



VOLCANIC EJECTA.
(*Prof.* SERVISS.)

[1] An old-established English journal published in the interests of architects and of builders.

[2] The Progressive Science Series : *Volcanoes : Their Structure and Significance*, by T. G. Bonney, D.Sc., LL.D., F.R.S., Professor of Geology at University College, London. John Murray ; and New York, C. P. Putnam's Sons, 1899.

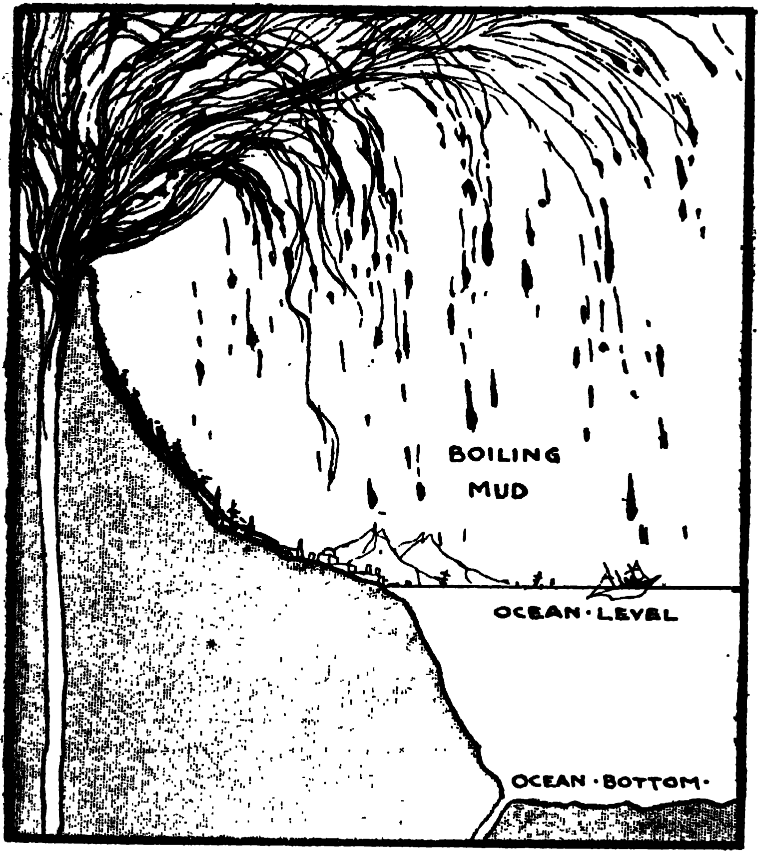
[3] Professor Shaler, of Harvard University, favours the theory that the lava bursts its way upward through the generature

firing of some monstrous gun. Water is also present in every volcanic product, and lurks unseen in the rock even after that has become solid' (*ibid.*). 'When it is remembered that the volume of steam is nearly seventeen hundred times that occupied in the form of water, and that the expansive force at the time of change is enormous, this seems an adequate cause for explosions' (p. 281). But, to permit the steam to expand, there must be a 'removal of pressure.' In this expression, all unknowingly, Professor Bonney indicates the final link in the chain of causation which Mr. Clements has discovered, and, I think, when the evidence for his discovery is fully submitted, it will be recognized as making the present subordinate causes explicable and trustworthy—as subordinate causes. Professor Bonney's whole sentence regarding 'removal of pressure' is as follows:—

'If, then, the removal of pressure allows any accumulation of water in the lava, which has been retained in a liquid condition, though far above its boiling point, to flash into steam, an explosion must result.' (p. 282).

Mr. Clements, as will be seen, does not question the introduction of water into the lava beds. He considers

of vapour from the water occluded in its mass. He points out that of the many hundreds of volcanic cones which have been known to discharge, nearly all are near the sea; and, furthermore, that the cessation of activity in inland volcanoes has been coincident with the disappearance of broad waters from their neighbourhood. Beneath the sea-floor the strata are constantly accumulating, and these strata as they are laid down have always water included within their mass. When, in the process of geological deposit, these strata sink low enough, say to 100,000 feet, they will probably have a temperature of 2,000 degrees Fahrenheit. Given the water, and the heat which must come to it from deep burial, and here are the fundamental conditions of a volcanic explosion—conditions absent where the blanket of strata is always wearing away, as in the case in land areas.—*North American Review*, June 1902.

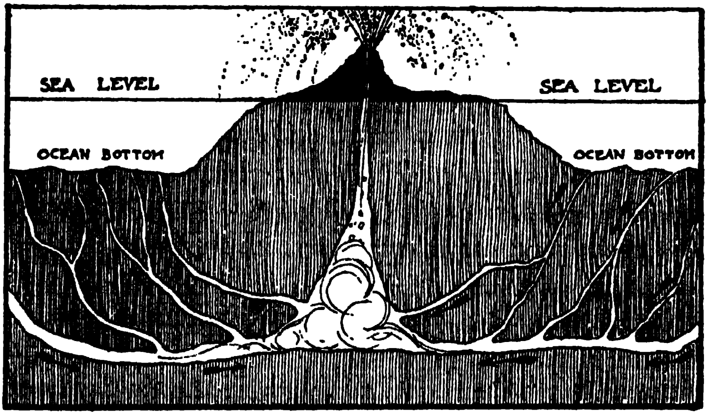


OUTPOURING OF BOILING MUD.
(*Prof.* Serviss.)

it quite likely that water may find its way into the superheated strata as a consequence of the 'removal of pressure,' and, maybe, through a fracture in the earth's crust caused by 'removal of pressure,' which instantly converts it into steam. For myself, after some study of superheated water-conditions in other circumstances, I think the evidence proves the existence of a large quantity of superheated water in the heated strata, possibly several times hotter than is needed, given space for expansion, for conversion into steam. Professor Bonney has no doubt on the point. 'We seem justified then,' he says, 'in concluding . . . that the actual eruption, the intermittent, though often long-continued, paroxysmal condition, *is due to water*, and that its withdrawal will mitigate and ultimately put an end to this, and so to the volcano' (p. 287). He declares that many authorities—among others, Mr. O. Fisher—considers this an adequate cause of the phenomena of eruption. While accepting these conclusions, the present writer is not convinced that these eminent authorities have satisfactorily accounted for the presence of the water in the under-world. Nor, later on in his book, is Professor Bonney himself completely satisfied. Percolation of the soil must be small, infinitesimal even, through the igneous rocks of volcanic regions. Such rocks can contain only ·09 of water per 1,000 parts, while chalk and other formations are really sponges through which the water from the surface filters readily—yet no volcanic outbursts occur in the chalk and cognate regions. Filtration appears to afford an insufficient explanation.

In discussing the problem as to how the water found its way into the molten rocks, Professor Bonney enters into explanation. 'Some have supposed that when it comes from the sea, the bed of that is fissured, and thus access is given' (p. 285). 'But,' he goes on to say, 'even in this case we must explain the beginning of the

eruption.' Following all who have gone before him in seeking for the beginning of explosive conditions, he looks downwards into the earth's interior; he never seems to imagine a cause above him, above the earth's crust, a cause continually acting in varying measure and sometimes with enormous force over restricted areas. 'In all,' he remarks, 'we must assume some agency to be already at work, forcing the incandescent mass upwards and throwing the overlying rock into a state of violent strain' (*ibid.*). This argument predicates the



HOW WATER MAY FIND A WAY TO MOLTEN STRATA.
(*Prof.* GARRETT P. SERVISS.)

original energy employed as being furnished from the inside of the earth, but, with our present knowledge of the properties of matter, is not this almost unthinkable? Is there anywhere such inequality of pressure 'that the melted matter is already undergoing such severe pressure that it would at once leap forth in large quantities if a leak were opened?' (*ibid.*). That hypothesis, stated in this form, is necessary until the array of Clementian facts is studied. But once these facts are studied, it is found that the 'turning of the handle' which relieves the superincumbent pressure and allows

the subterranean forces to exert themselves is done above the surface; and that the moon and sun, in conjunction, by the exercise of their maximum 'pulling' force on the atmosphere, and even on the particles of the solid earth itself, in the proportion of two parts by the moon and one part by the sun, are the really operative cause; they 'turn the handle,' and provide for the explosive forces a free vent.

2. 'The occurrence of molten rock has yet to be explained' (p. 288). Various theories are put forward, *ex. gr.*:

(*a*) Dr. Daubeny's hypothesis: The mass of the earth most probably consists of bases still unoxidized, combination with that element having taken place only in its outer portion. 'The globe, in fact, might be compared to an orange, the skin of which represents its oxidized envelope. But combination must be going on continuously, for water is always penetrating downwards, not only carrying with it oxygen in solution, but itself also undergoing decomposition. Thus there is no difficulty in supplying the requisite amount of oxygen. But chemical combination develops heat and, if this is taking place on a great scale, it may be sufficient to melt neighbouring masses of rock.'

These causes are declared to be inadequate, 'though true.'

(*b*) 'Magnetic currents to produce local melting of the rock' (p. 288). '... There is not evidence to show that these currents are sufficiently localized or strong enough to produce any material elevation of temperature in the rocks through which they pass' (p. 290).

(*c*) Mechanical causes (discovery and elucidation of which are specially associated with the name of the late Mr. Mallet, and stated in full by him in *Philosophical Transactions*, 1873). 'The cooling of the globe,' 'the solid heat constantly breaking up and probably sinking'

(p. 291), and, finally, as the solid crust thickened, 'the state of tension would be gradually exchanged for one of compression' (*ibid.*), and, consequently, 'the tangential thrust on each face of a cubic mile of the earth's crust is equal to two thousand times its weight, a pressure which would suffice to crush the hardest of rocks' (*ibid.*). Plausible as is this theory, it is dismissed. There is a 'total absence of any confirmatory evidence in Nature' (p. 283).

(*e*) '. . . The evidence which we can obtain by a careful study of the rocks themselves not only affords no support to Mr. Mallet's hypothesis, but is even hostile to it' (*ibid.*).[1]

Some further conclusions by Professor Bonney may be stated in his own words, seeing that they lead up to a statement that all the existing theories are insufficient to explain the phenomena; a 'physical principle, yet undiscovered,' is demanded, and he concludes with certain hopeful words which I venture to submit have already—long before the period he names has arrived—found fulfilment in the application, to the faulty and insufficient hypotheses which Professor Bonney marshals, of Mr. Clements' discovery. Professor Bonney, in the last words of his book, says:

'Those among us who live to see the twenty-fifth year of the coming century are likely to be much wiser than we are now, for by that time many mists should have vanished and difficulties been surmounted.' (p. 333).

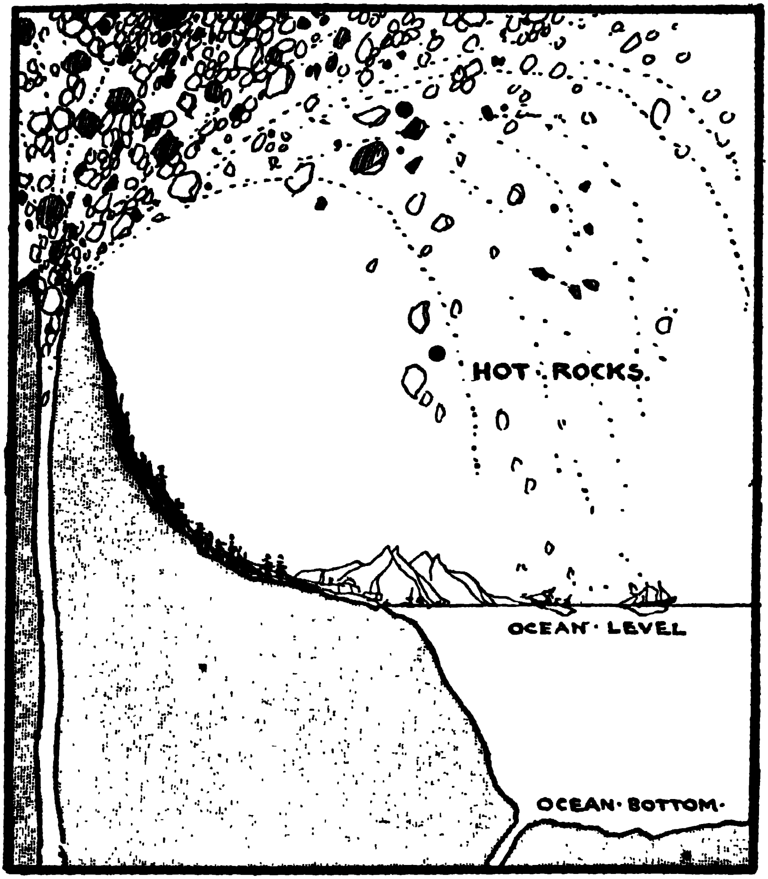
The 'further conclusions' to which I refer are as fol-

[1] Professor Bonney thus emphatically expresses himself: 'Here I venture to speak with the confidence of personal experience, for, probably, few geologists have examined under the microscope so large a number of rocks which have suffered from earth movements and been greatly crushed as myself, and I have no hesitation in affirming that I have never seen the slightest approach to fusion in any part of such a rock' (pp. 293, 294).

lows: 'We are compelled, as already said, to assume the existence of pressure, in some form or other, in order that the molten material may be brought up to the surface. The expansive force of steam, as we have pointed out, is an important agency in many cases; but this probably becomes more potent when the mass is coming near to the surface, and is a prime factor in the explosive phenomena. We seem to require, in addition, indeed as anterior agencies, forces to squeeze or to push the magma from place to place [1] in the crust. The not infrequent, steady, and, for a time, continuous, flow of lava from a fissure, and its intrusion as sheets, laccolites, etc., suggest that the fluid mass is forced outwards, as we can squeeze oil-paint gradually from a compressible tube.'

'... So far, then, as our present knowledge goes, we seem justified in asserting that water plays an important part in producing the explosive phenomena of volcanic eruptions, and possibly in modifying the fluidity of magmas; that the lavas, scoria, etc., discharged during such eruptions (no less than the igneous rocks which never reach the surface) represent portions of the original material of the globe, which have been only very slightly, if at all, affected by melting down any deposits of sedimentary origin; that this material, even if it has temporarily passed into a solid condition, always has been kept at a temperature not far from its melting point; that the different types of igneous rock may be the results, in some cases, of a stratified precipitation or arrangement during the original condensation of the globe, but more often, in all probability, of some process of differentiation during later stages of its history; and, lastly, that the outflow of these magmas, the intrusion

[1] Or, may I suggest the words, 'to relieve the pressure on the surface by tangential pull of moon and sun and thus allow of expansion and consequent escape.'—Wm. D.



EJECTION OF HOT ROCKS, AS FROM MONT PELÉE.
(*Prof.* GARRETT P. SERVISS.)

of the so-called plutonic rocks, the opening out of volcanic orifices of all kinds, are primarily due to a rupture of the crust, for *at present* [1] no other cause can be discovered than strains set up in consequence of the secular cooling of our planet.'

'. . . But, in regard to the great physical questions which bear upon the causes of vulcanicity, the progress which has been made of late years, though undoubtedly great, has been more in pioneering work than in constructing any complete theory. Much error has been cleared away, paths, as it were, having been hewn into the tangled thicket, the broad lines of investigation have been traced, many important facts have been ascertained. Perhaps the principal causes have been surmised, but, at present we generally can affirm a fact more confidently than we can offer an explanation; and *there may be some physical principle which as yet is undiscovered, or the importance of which has hitherto been overlooked.*' [1]

I have marked many passages in works by Professor Judd [2] and Milne,[3] and also in Sir Archibald Geikie's article 'Geology' in the ninth edition of the *Encyclopaedia Britannica.* Professor Bonney, however, latest in order of time, has so thoroughly dealt with volcanic causes as to make it necessary to reproduce but a very few of my citations. There is this in common with all that has been abstracted: in dealing with the causation of earthquakes and volcanic eruptions the authorities are dissatisfied, and look for a potent and controlling cause which, in alliance with other causes that are indisputably scientifically demonstrated, shall make these phenomena

[1] The italics are not Professor Bonney's, but mine.—WM. D.

[2] International Scientific Series. *Volcanoes: What They Are, and What They Teach,* by John W. Judd, F.R.S., Professor of Geology in the Royal School of Mines. Kegan Paul, Trench, Trübner and Co., 1893.

[3] International Scientific Series. *Seismology,* by John Milne, pp. 24, 25.

understandable and allow of their occurrence becoming predictable. Mr. Clements, I submit, satisfies the desire inasmuch as he fulfils the conditions precedent to full explanation. Most strangely as it seems, Mr. Milne, when dealing with the causes of earthquakes, deliberately turns away from the contemplation even of the most potent of these causes. He says: 'In the present chapter there is no intention to try and deal with gravitational effects of the sun or moon, or with the effects of barometrical and other loads—the stresses due to which may result in yielding being more frequent at one season than at another,—but only to refer to causes which bring about conditions to which earthquakes are more directly attributable.' [1] As the facts stand this is a complete inversion of the scientific order of things. The secondary and strictly consequential incidents in earthquake causation are regarded as though they were primary causes, and the door is shut by this great scientist against investigation along any and every line likely to lead to a solution.

On the need for some great operating cause above and beyond that which already exists, Professor Judd (pp. 290–292) says:

'The old notion that mountain-chains are due to a vertical upthrust from below finds little support when we come to study with due care the positions of the rock-masses composing the earth's crust. On the contrary, we find that mountain-ranges are usually carved out of the crushed and crumpled edges of strata which have along certain lines been influenced by great mechanical strains and subjected to more or less induration and chemical alteration. When we compare these folded and contorted portions of the strata with those parts of the same beds which are not so affected, we find the effects produced in the former are not such as would result from an upthrust from below, but from movements by which a tangential strain would be brought about. If we imagine certain

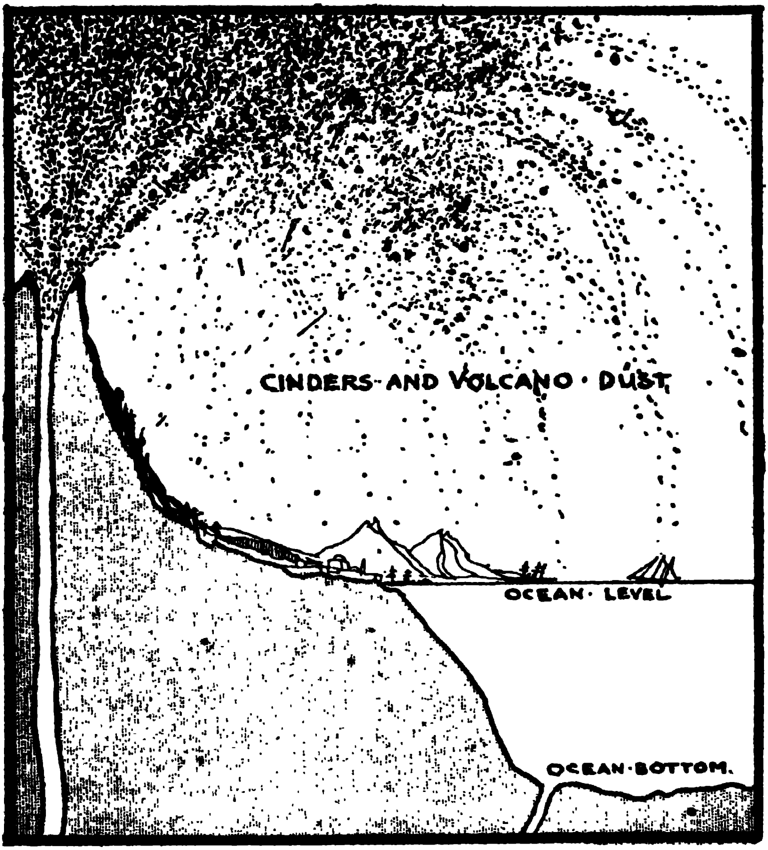
[1] *Ibid.* pp. 24, 25.

lines of weakness to exist in the solid crust of the earth, then any movements in the portions of the crust between these lines of weakness would cause crushing and crumpling of the strata along the latter.

'Recent investigations of Dana and other authors have thrown much new light upon the question of the mode of formation of mountain-chains, and the relation between the movements by which they are produced, and the sudden and violent manifestations of force witnessed in volcanic outbursts. We cannot, perhaps, better illustrate this subject than by giving a sketch of the series of operations to which the great Alpine chains owe their origin.

'There are good grounds for believing that the great mountain-axis of Southern Europe, with its continuation in Asia, had no existence during the earlier geological periods. Indeed, it has been proved that all the higher among the existing mountain-chains of the globe have been almost entirely formed in Tertiary times. The reason of this remarkable fact is not far to seek. So rapid is the work of denudation in the higher regions of the atmosphere that the elevated crags and pinnacles are being broken up by the action of moisture and frost at an exceedingly rapid rate. This fact is attested by the existence of those enormous masses of angular rock-fragments which are found lodged on every vantage-ground among the mountain-summits, as well as by the continually descending materials which are borne by glaciers and mountain-torrents to the valleys below. Where such a rate of disintegration as this is maintained, no elevated mountain-crests could exist through long geological periods. It is true we find in all parts of the globe relics of many mountain-chains which were formed before the Tertiary period; but these have by long-continued denudation been worn down to "mere stumps." Of such worn-down and degraded mountain-ranges we have examples in the Scandinavian chains, and some of the low mountain-regions of Central Europe and North America.'

Professor Milne, in Chapter XI of *Seismology*, where he deals with Seismic Frequency and Periodicity, often comes near the true line of investigation, but, in the abundance of his authorities, altogether fails to discern the path which would have led him to certitude. Contra-



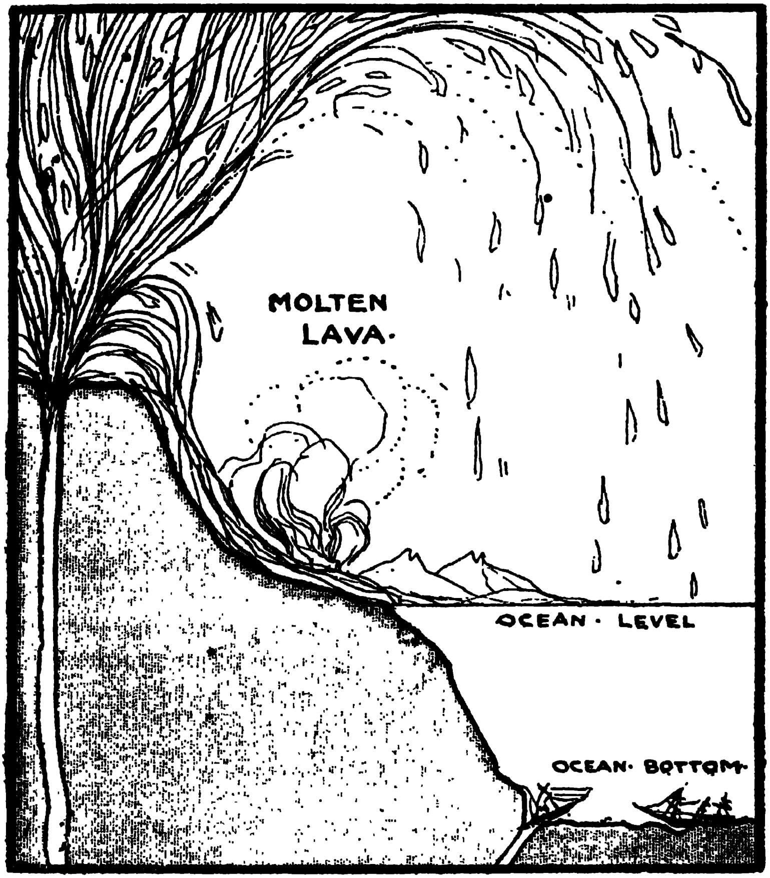
EJECTION OF CINDERS AND VOLCANIC DUST.

(Prof Garrett P. Serviss.)

dictoriness in observation is painfully apparent, *ex. gr.* (p. 208). Professor Alexis Perry, of Dijon, asserted that earthquakes were more frequent at new and full moon, while 'Julius Schmidt found a diminution of earthquakes at full moon.' Professor Milne himself says (p. 209): 'When the occurrence of earthquakes is examined relatively to the position of the sun, which is equivalent to determining their relative frequency at different seasons and months, we find that the greatest number of shocks have been recorded during the winter months'—an observation which has this of merit in it that the sun during the winter months is nearest to the earth, and has therefore more 'pull' to lend to the moon, when that orb is in line to exercise her greatest power.

That atmospheric pressure had no small part in the production of phenomena is indicated by the researches of Mr. Davison, whose inquiries show that 'in ten districts the maximum epoch of seismic and barometric annual periods coincide' (p. 210). Again: 'The general rule is that seismic and barometric maxima coincide' (p. 211). Dr. Fred Seidl is also quoted to 'show the marked relationship that exists between earthquake frequency and the state of the barometric gradient in Europe' (*ibid.*). One authority (Knott), in a number of conclusions, makes it clear that lunar influence had to do with earthquake phenomena. Knott's seventh and final conclusion is: 'Nevertheless, because the maximum frequency falls near the time of perigee, there is some support to the view that earthquake frequency and the earth distance are closely connected' (p. 215).

Mr. Milne himself, however, will have none of the lunar influence. 'One thing, is certain,' he says, positively, 'namely, the comparative insignificance of periodicities that may possibly be attributable to lunar stresses' (*ibid.*).



OVERFLOW OF MOLTEN LAVA.
Prof. Garrett P. Serviss.)

Later (pp. 275–283) an attempt is made to associate earth tremors and a low barometer. From the passages cited or adopted by Professor Milne the following may be quoted:

'One important observation was that tremors were nearly always at a maximum when the barometric gradient was steep, no matter whether at the place of observation the barometer was high or whether it was low' (p. 275).

'Another investigation has revealed the fact that whenever there is a barometrical change of six or more than six millimetres in eight hours (which usually occurs with a falling barometer), tremors are pronounced. Earth tremors may therefore be connected with the rate of change of pressure' (p. 276).

'One explanation of the earth's tremors refers them to barometrical pressure and the rapidity of its changes' (p. 282).

A table, prepared in 1885 for Central Japan,

'shows a close accord between the times at which tremors were pronounced and gradients were steep. The steeper the barometric gradient across a district, the more likely it is that tremors should occur, and in Japan it has invariably happened that where there has been a gradient of 6 mm. per 120 geographical miles tremors have been recorded' (p. 283).

'Both in Japan and Germany slow changes in position of a horizontal pendulum have been recorded as accompanying changes in barometric pressure' (*ibid.*).

'At Wilhelmshafen von Rebeur-Paschwitz found that a change of one mm. in the barometric pressure corresponded to a change of 0·29 second in the vertical' (p. 283).

So far as such fragmentary evidence as is recorded can be followed it would seem that the tremors referred to follow transit, parallax, and declination, of both moon and sun,—thus, in a general way, supporting the Clements thesis. Where definite data is furnished it is not difficult to account for earthquakes on the principles already enunciated. Take, by way of example, the only one (out of a number referred to) mentioned with scientific

precision; it occurs on p. 204 of Mr. Milne's book. In Tokio on June 20, 1894, an earthquake occurred. The formula to account for the position of moon and sun over Tokio in especial attractive 'pulling' power is the following:—

19/6/94.	● Transit	Parallax	Moon (Dec.)	Sun (Dec.)	Moon	Sun
	13·28	53·59	26·48	23·27	80°	90°

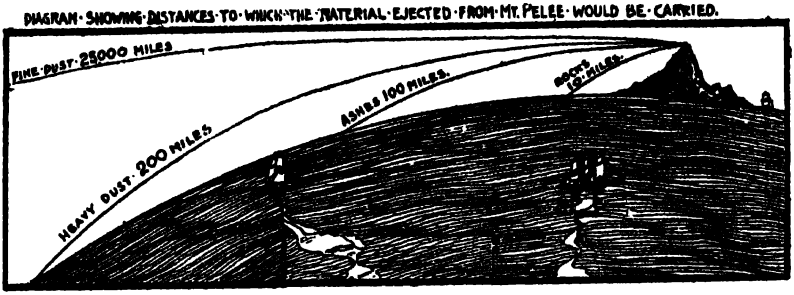
Tokio 141° E. and 35° 30′ N. Lat.

The earthquake shock occurred, according to calculation, at 5 a.m. on June 20, the moon being 80° and the sun 90° from Tokio at that time.

A terrible disaster on October 28, 1891, is mentioned on the same page, but no particulars are given as to place of occurrence. A reference to luni-solar influence is not, therefore, possible there.

A fresh chapter will fitly begin a consideration of earthquakes and volcanic eruptions from the point of view furnished by Mr. Clements in the application of his discovery to this class of phenomena.

DIAGRAM · SHOWING · DISTANCES · TO · WHICH · THE · MATERIAL · EJECTED · FROM · MT. PELEE · WOULD · BE · CARRIED.



Prof. GARRETT P. SERVISS.)

APPENDIX

CURIOUS FACTS ABOUT EARTHQUAKES AND WHAT CAUSES THEM.

BY GEORGE WALTER HALE.

(From the *New York American and Journal*, May 18, 1902.)

AT the present writing accounts pertaining to the phenomena witnessed at the time of the destruction of St. Pierre are very meagre, and it is probable that they will be very misleading and imperfect, until the scene is visited by some person who understood the cause of such phenomena and has investigated into it.

The writer having discovered the origin of plutonic earthquakes some fifteen years ago and having devoted many years to the subject exclusively, now writes with the hope that a correct knowledge may be obtained of these, the most fearful of earthly events.

While there is little doubt but that the destruction of St. Pierre was complicated with volcanic phenomena, owing to numerous volcanoes in the vicinity, it is a fact well known by those who have examined into the conditions attending earthquakes, that volcanoes have nothing to do with the inception of these shocks.

There is no doubt but that, in this instance, the terrible destruction was caused by something quite distinct from volcanic action.

Volcanoes do not cause earthquakes, save slight ones, but the cause of earthquakes often sets volcanoes into violent paroxysmal or spasmodic activity, and future investigation

of this cataclysm will disclose whether or not this cause was active here.

No one aside from the writer pretends to explain the origin of this phenomenon, and the general knowledge of the subject is remarkably limited, as the reader will find should he endeavour to inform himself upon the subject.

There are but two works in English that furnish any information upon the phenomena of earthquakes, so far as the writer knows—Mallet's *Catalogue of Earthquakes* and Boscowitz's *Earthquakes*, an indifferent translation from the French.

The subject should be of great interest, however, as the reader may rest assured that in all probability the same kind of fire that destroyed St. Pierre will ultimately destroy everything upon the earth, as foretold by Scripture, and that such destruction is very certain to come, just as foretold.

* * * * *

St. Pierre was destroyed, with little doubt, in the same manner that Sodom and Gomorrah were, and as fifty other towns have been destroyed during historical times.

Mr. Russell, a late writer upon lakes, gives as the chief cause of their origin earthquakes and meteors, though he had not discovered that the earthquakes themselves were caused by impact of enormous meteors, and by such cause only can every detail of the phenomena of earthquakes as witnessed be explained.

Only by such means could the sudden and complete destruction of St. Pierre have been accomplished, for volcanoes act slowly, as at Pompeii, where the people in greater part escaped.

Mountains are not blown into fine dust as has been supposed to be the case at Krakatoa, but hundreds of them are driven into the earth when earthquakes occur, and the meteors were seen before they fell in the Straits of Sunda, though they are rarely seen when falling, or before, and then only as a great stream of fire by night usually attended or followed by a shower of small meteors.

Large meteors are not drawn in by the attraction of the earth, in falling, like an aerolite; they either strike it perpendicularly or pass on into space, hence falling so swiftly, the eye cannot fix them except it be by a long, thin, trailing

cloud sometimes, and generally the sky is darkened by vapours in advance.

Space being dark we can see no dark object above the air, so that the opportunity to see them is for a second or two while they are passing down through the air (only).

There are no instances where they are seen in the air save where they fall more or less tangentially as at Melfi, but they have been seen at a distance as at Mendoza, when on fire, or at Krakatoa, as spots upon the sun.

They rarely fall tangentially, or across the surface of the earth, as at the Dead Sea, ploughing a great trough with no depth at one end and thousands of feet in depth at the other, of which the great valley of the Lunar Alps upon the moon furnishes a fine illustration.

The lakes of central New York are such fiord lakes, and many will be found upon the earth, though, like the moon craters, the spot, if undisturbed by later impacts or erosion, is either oval or round, as will be found, and if oval the end where the body passes into the earth falls in irregularly.

Only in solid rock substrata do the cavities remain open. In alluvium they always close unless the bodies are very large, as at New Madrid, Mo., where the great earthquake of 1811 left a number of lakes.

At this earthquake the ground was left covered with a white powder and a strange white phosphorescent fog lasting a whole season followed it. The same followed Calabria and Lisbon, and these shocks came on about the same parallel of latitude and twenty-eight years apart. The orbital period of Saturn, which, the ancient Chaldeans said, governs earthquakes, which is true, though not so many as Jupiter.

♄ Most comets fix their orbits to these two greater planets, and the sun-spots (due to meteor impact) are regulated by them as well.

♃ These bodies, of course, fall very suddenly, and occasionally numbers of great rocks fill the air, though this does not occur often, fortunately, as at Bandaisan, Japan, in 1889, where the main body, composed of a coarse sand-rock, struck a mountain and dashed about one-third of it some four miles across the surrounding region. The sand came in such a shower that the sky was absolutely dark for about an hour. The sand came so swiftly that it stuck in the skins of the inhabitants, and was so hot that they were burned to death by

it, while the portion of the mountain that remained intact was shot full of great rocks that buried themselves ten feet deep in the earth.

At the Charleston earthquake a few flints fell and a peculiar yellowish viscid substance, smelling strongly of sulphur, was found upon the ground afterward, the same being found with aerolites.

Small bodies such as fall further north cannot be seen when they fall perpendicularly; they are called thunder-bolts, and one fell in Fairmount Park a few years ago, causing a slight earthquake in New York. They generally penetrate below water-level in the earth, so that they cannot be dug out without great expense.

At the time of the Lisbon shock one part of the meteor struck an Arab town in Africa, and the earth leaped into the air on each side, forming two mountains as described, and these fell upon the town and destroyed it as supposed, but the town was thousands of feet in the earth, as we may know from another part that fell in Lisbon, the greatest body having fallen at sea, the earth-waves began to throw down the buildings of the city, and the people by thousands ran down upon a new marble wharf and many got into boats, when suddenly the boats, the people and wharf all disappeared with a frightful shock, and a great chasm was left in place of them.

The Tagus River formed a mighty whirlpool and flowed into and filled the cavity formed, and, what was considered most remarkable at the time, no hat, oar, boat or vestige of anything that went down ever rose to the surface of the water, nor could soundings be got with a line two thousand four hundred feet in length.

Two considerable towns in South America disappeared in this manner some thirty years ago, lakes taking their places.

During one great shower of these bodies in the seventeenth century, Catania and a number of cities and towns of Sicily were turned into lakes.

This earthquake left the air filled with dust, as appears was the case at St. Pierre, the lake-waters being filled with petroleum and sulphur as usual with all newly formed lakes.

These bodies fall upon certain belts of the earth as they do upon the sun and Jupiter, which may be marked by the spots,

but the earth's equator is inclined to a greater angle with the ecliptic, so that, as with the sun, the spots are more widely distributed than upon Jupiter, the earthquake belts upon the earth are very wide, and the fall of the bodies seems to be governed by certain isodynamic lines of magnetism.

The Caribbean Sea lies directly under one of these belts, and north of this one appears to cross from Charleston bearing northerly across the United States.

The belts do not appear to follow lines of latitude, but seem to be governed by polar or magnetic conditions, and large bodies do not fall north of the fortieth parallel in the United States, while in Europe and Asia they extend far to the north, and they seem to fall near the poles not infrequently.

Of course many cities are destroyed by the shock of impact upon the earth at long distances from the spot stricken, and such may be the case of St. Pierre. Mendoza with nearly its entire population was destroyed by a great red and blue meteor which was seen the night previous to its fall, and the town was about seventy-five miles distant from the point of impact.

Where the cavity closes, the spot may be marked by the total disappearance of buildings, as at Ischia in one place; at Calabria some buildings were afterwards dug out and were found to be crushed flat.

The sun is generally obscured before an earthquake, and the preceding gases and vapours may begin to arrive before the shock. They are generally inflammable, and terrific explosions overhead usually attend all earthquakes.

At Cumana Von Humboldt states a red mist obscured the sky so that the moon appeared only as a faint aureole just before the shock, and a black column of cloud towered into the sky as far as the eye could see, directly over the point of impact.

A terrific blast of wind is always felt near the point.

These gases often set volcanoes into action before the stroke. Sometimes days or even weeks before, they turn the sky to a red, yellow, or grey colour, and on the day of Krakatoa the sun at Venezuela was turned blue; at other times it becomes green or red.

The dust or smoke hovering over and hiding St. Pierre, according to newspaper accounts, suggest the total disappearance of that city, and the suddenness of the blow, together

with the earthquake mentioned, leaves no doubt as to the cause of this terrible eruption, as it is termed by those who think it volcanic in its origin.

It would appear that the meteor-impacted material as a factor in the making of the members of the solar system is believed to have played an important part. In *Nature* of October 16, 1902, a review appears of *Der Untergang der Erde und die Kosmischen Katastrophen*, von Dr. M. W. Meyer.[1] From the review I take the following summary of, and comment upon, Dr. Meyer's views because of the striking manner in which they make clear the possibility of that having occurred in the past history of the globe, which Mr. Hale asserts happened in Martinique and St. Vincent in May 1902. *Nature's* reviewer writes:

'With his centres of condensation and space charged with dust and meteors, Dr. Meyer apparently follows the suggestions of the late M. Faye, and assumes that many meteors moving in eccentric orbits strike against the nucleus and are absorbed by it, maintaining an elevated temperature in the central body by impact. Our moon and the satellites of other planets seem to have come into being simultaneously with the primaries, being formed from secondary rings, the separate existence and stability of which are not explained. But as condensation proceeds on the secondary rings, the bodies so formed necessarily cool more quickly than the larger planetary masses, and the precipitated meteoric matter, which is absorbed by the glowing and fluid planets without any difficulties leaves holes in the thin crusts of the satellite, which is not yet sufficiently rigid to resist. The result is that phenomena resembling lunar craters are produced. These craters, therefore, are not the result of ejections resembling volcanic eruptions from within, but are the results of action from without. Further than this, the matter carried into the body of the moon will in its turn be melted in the heated interior; consequently this thin crust will no longer be able to support the internal pressure, and rents or fissures of the

[1] Berlin: Allgemeiner Verein für Deutsche Litteratur, 1902.

hardened exterior will take place, and this is the cause of the bright streaks or radiations which can readily be seen on the most superficial examination of the moon. It might be urged in opposition to this view that the molten matter ejected from the interior must soon cool, and not only destroy the traces of the meteoric bombardment, but would also thicken the crust and tend to prevent the penetration of fresh meteors. If one asks why the earth or Mars does not show similar signs of precipitated matter, Dr. Meyer is ready with his answer. By the time that the greater mass of a planet had sufficiently cooled, all the larger débris, the results of the original collision, had been absorbed, and the smaller masses either fell upon the stiffening crust without penetrating it, or were volatilised by friction with the atmosphere, which in those days, it is suggested, was more dense than at present. And if anyone, still unconvinced, asks how it is that Jupiter, for example, can drink up all the matter in a cosmical ring extending into indefinite space, and yet refuses to swallow the small mouthful which in the form of the fifth satellite tantalisingly tempts its capacious appetite, the answer is, Wait. All the satellites will eventually be drawn in and form an integral portion of their respective primaries, just as these in their turn will be absorbed in the sun, to be followed again at immense intervals of time by the crashing together of defunct suns producing a larger set of planets with a larger and hotter sun, a solar system on a vaster scale than that in which we play our little part. And so growing in grandeur but diminishing in number, the final catastrophe will come, when there are no more suns to produce collisions, and one huge body cooled to the zero of space, void of available energy, will mark the final outcome of cosmical motion.'

CHAPTER III

The Part Taken by the Moon and Sun in the Causation of Earthquakes and Volcanic Eruptions

The Incident which led Mr. Clements to Investigate the Causes of Earthquakes.
Newton's Theory of Gravitation as Exhibited in the Attraction of Moon and Sun on the Earth the Final Determining Cause of all such Phenomena.
A True Theory must be Applicable to Every Known Case of Earthquake.
The Strange Antipathy Exhibited towards the Moon as a Determining Factor in Terrestrial Happenings.
Sound Principle on which the Clementian Theory is Based.
Death-roll of Earthquake Shocks during Historical Period Smaller than a Decade of Famine Deaths in India.
The Shocks of the Past Thirty years in Britain and Elsewhere.
The Moon and its Cycles—Nodal, Apsidal, and Phasial.
Invariable Law Manifested in the Causation of Earthquakes.
Nine Principles of Attraction.
The Course of Sun and Moon from May 1 to May 31 Delineated, and their Relationship to Mont Pelée Diagrammatized.
Each Great Eruption shown to be Coincident with Special Positions of Moon and Sun.
Were the Positions merely Coincident? If not, have like Combinations in the Past Produced Eruptions?
Martiniquè Earthquakes from 1657 to 1902.
Singular and Striking Confirmation of the General Law.
Earthquakes and Volcanic Eruptions, January to July, 1902, Twenty-nine in Number.
Shocks and Eruptions at Fort de France, Martinique.
Graphic Representation of Course of Moon and Sun over the Lesser Antilles in August 1902.

Reason why Martinique Eruptions chiefly confined to May and August.
Record of Fifty-seven British Earthquakes, from 1882 to 1901.
Earthquakes Occur at 3 a.m. or 3 p.m., 6 a.m. or 6 p.m., and 9 a.m. or 9 p.m.
Illustrations Bearing out this Significant Fact.
Comparison of two British Earthquakes—Colchester and Jersey.
Earthquakes Considered in Detail and Diagrammatized.

Hereford	Shepton Mallet
Calcutta and Hereford	South Wales and Cornwall
Lynton	Leicester and Eastbourne
Rhondda Valley	Inverness
Comrie (2)	
Pontypridd	

Earthquake in Assam in 1897.
Detailed Comparison between Assam and Hereford Shocks, with Two Diagrams.
What the Earthquakes in the British Isles Prove.
Analysis of Earthquakes Occurring under like Conditions of Transit and Lunar and Solar Declinations, in Series.
Diagrammatic Presentment of the Earthquake at Salonica.
Lisbon Earthquake of 1755: Position of Sun and Moon in Direct Accord with the Clements Discovery.
Kashgar Earthquake and Sicilian Cyclone, with Five Diagrams, Compared.
Summary of Causation of Earthquakes and Storms.
Professor Milne and Water Infiltration to Molten Strata.

Appendix :

I. Diagrammatic Representations of Lunar and Solar Positions during 1902—Earthquakes at

Nova Scotia	Cheadle (June)
Mexico	Cheadle (July)
Croatia (January)	Bandar Abbas
Croatia (May)	

II. The Moon's Tangential Pull.

'The course which analogy would have recommended for our knowledge of tides would have been to ascertain by an analysis of long series of observations the effects of changes in the time of transit, parallax, and declination of the moon, and thus to obtain the laws of phenomena; and then to proceed to investigate the laws of causation.

'Although this was not the course followed by mathematical theorists, it was really pursued by those who practically calculated tide-tables; and the application of knowledge to the useful purposes of life being thus separated from the promotion of the theory was naturally treated as a gainful property, and preserved by secrecy. . . ,

'The mode in which these secret methods were invented was that which we have pointed out—the analysis of a considerable series of observations. Probably the best example of this was afforded by the Liverpool tide-tables. These were deduced by a clergyman named Holden from observations made at that port by a harbour-master of the name of Hutchinson, who was led, by a love of such pursuits, to observe the tides for above twenty years, day and night. Holden's tables, founded on four years of these observations, were remarkably accurate.

'At length men of science began to perceive that such calculations were part of their business; and that they were called upon, as the guardians of the established theory of the universe, to compare it in the greatest detail with the facts.'—*History of the Inductive Sciences* by DR. WHEWELL. 1837, vol. ii. p. 248.

THE report that an earthquake had occurred in the west of England on the morning of December 17, 1896, led Mr. Clements to apply the knowledge he had already turned to account in the study of atmospheric conditions and the control of weather phenomena to a special investigation, in order, if possible, to discover the cause of the phenomenon. As has already been indicated in the preceding chapter many theories have been propounded with regard to the causation of earthquakes, one at least fantastic and seemingly far-fetched, while the others, more or less plausible, do, undoubtedly, account in part for the phenomena described. Not one of the many eminent men of science who have written on the subject pretends to wholly explain either earthquakes or volcanic eruptions. One and all cry for more light before they are called upon to afford an explanation which they themselves would deem satisfactory. In order to find general acceptance a theory which professes to explain earthquakes should be found capable of application to every recorded earthquake.

Of earthquakes there are many varieties, so far as outward manifestations are concerned, and the difficulty hitherto has been that no theory advanced will explain their almost infinite variations. Where so many students of natural phenomena have tried to unveil

the hidden causes it might be supposed that any theory which endeavoured to explain all the difficulties hitherto unsolvable, and in support of which much scientific proof was produced, would be heartily received in scientific circles. Past history does not make one too hopeful in this respect.

From observation and calculation Newton deduced the theory of gravitation. Many years passed before his discovery was generally accepted by the scientific opinion of his day. It was submitted to all sorts of tests, and it was only eventually accepted as a fundamental law of Nature when it was found that the movements of every celestial body with which men were then acquainted could be explained and satisfactorily accounted for by the Newtonian theory. This is as it should be. Before being accepted a theory should be subjected to every conceivable test. If, however, the tests are applied, and if it be found that, in every instance, they are sufficient to account for all phenomena, that theory ought to receive full acceptance, no matter how profoundly it may run counter to generally accepted ideas. It will be seen, later in these pages, that these comments are not merely enunciated as remarks which, because of their evident truth and common sense, command acceptance, but because they have a bearing on what follows. For ourselves—that is for Mr. Clements and the present writer—we hold that in the subject under consideration any theory that may be proposed must explain and account for every known case of earthquake upon the grounds of luni-solar causation. Mr. Clements' theory must answer to this test if it is to command general assent and, from a theory, become a demonstrated and accepted addition to scientific knowledge. As the external manifestations of hitherto recorded earthquakes have been infinitely varied, it would be impossible for any theory except the correct theory to apply to every case.

Hitherto the cause of earthquakes has been enveloped in mystery. Notwithstanding that fact, it is obvious that there must be a law under which these phenomena, in common with all other phenomena, are manifested, and there can be no doubt but that, sooner or later, this law must be discovered. The causation of tides was a mystery until Newton threw the needed light upon what was, without that light, inexplicable. It was long suspected that the moon had some mysterious connexion with the tides, but until Newton's master-mind grappled with the subject the connexion could not be thoroughly and satisfactorily established. The sun, it is true, assists in the production of the tides, but the influence of the moon is predominant. This was the common opinion before scientific knowledge put it beyond all doubt, and it was justified. Similarly, it has long been supposed that there is some connexion between earthquakes and the moon. Scientific men have been too ready, without adequate examination, to pooh-pooh such a relation. There is this to be said by way of excuse for them, that, until now, no coherent or fully satisfactory theory has been advanced. Guesses have been made, statements have been advanced, but sufficient investigation had not been made to justify assertion. In the present instance, the evidence in respect to the phenomena described was first obtained; that evidence was made the subject of severe test year after year, and upon the tests thus made was built the conclusions which, it is submitted, meet all the necessities of the problem. It is here sought to prove that there is an intimate connexion between the earth's satellite and the causation of earthquakes (in common with the causation of all meteorological phenomena and volcanic eruptions), and that the influence of the sun is also involved.

No part of the earth's surface is exempt from earth-

quakes, but in their most violent form at the present time they are confined to certain localities such as the south of Europe—especially Italy and Greece, Japan to the east of Asia, certain parts of the Andes, with isolated action in the islands and bed of the Pacific Ocean, Central America, the islands of the Caribbean Sea, the East Indian Archipelago, the United States, India, and Persia.

Our own country, moreover, does not escape from the attractive power which, in times past, exerted so great an influence in the shaping of the world's surface, and still accounts for earthquakes in their final stage.

During fifteen years, from 1881 to 1895, forty-five earthquakes were recorded in Great Britain, four-fifths of which occurred immediately on each side of the line of 3½° West longitude, which was once the centre of a system of volcanoes extending from Caithness to Devon. It is only once in every dozen years or so that an earthquake which is destructive to life and property occurs in England; in many other parts of the world they are of a more serious nature and are more frequent.

Earthquakes have caused great changes on the earth's surface. They have formed new valleys, lakes, islands, and river-courses, and have obliterated old ones. They have destroyed towns and whole districts, causing immense damage to property; and it is calculated that more than thirteen millions of human beings have perished by their agency.[1] In 1755 one hundred thousand lives were destroyed in Lisbon and Calabria alone. Although there were only thirteen hundred lives lost by

[1] These figures show that earthquakes and volcanoes, destructive as they often are, are not among the most grievous of the scourges to which mankind is subjected. Famine in India, during the last twenty years of the nineteenth century, carried off more human beings than these destructive agencies, which are the occasion of much human terror, have been responsible for throughout the whole historic period.

the earthquake that occurred in India on June 12, 1897, there was great destruction of property, as it was of exceptional force and covered a very large area of country from west of Calcutta in the Lower Provinces of Bengal to the extreme east of the Province of Assam.

On December 17, 1896, at 5.35 a.m., a smart shock was experienced over a large area in the western part of England, being most severely felt at Hereford. The shock was perceptible from Lincoln to Preston towards Kendal, through Wales by Bristol to Yeovil, and in North London. Within this area one hundred and sixty shocks were recorded during the last seventy years. Then, again, quite recently—in May 1902—the civilized world was appalled by the terrific earthquakes and eruptions which took place in Martinique and St. Vincent in the West Indies, of greater or less intensity during the greater part of the month of May, having commenced on the 3rd and terminated on the 27th, culminating on the morning of May 8, when forty thousand people perished in the town of St. Pierre, five miles from Mont Pelée, the seat of the eruption.

THE MOON AND ITS CYCLES

Before proceeding with our record of earthquakes and the application of Mr. Clements' discovery thereto, an explanation of the discovery and its application may be given here in brief. The discovery will be set out in full detail later when weather phenomena are under consideration; that part which relates to earth-tremors may now be stated. It is generally known that the moon revolves round the earth in an ellipse, of which the centre of the earth is one focus. The plane of this ellipse is not stationary with respect to the earth's axis; it oscillates about the plane of the ecliptic and takes 18·6 years (or eighteen years and seven months) to complete the movement. This is one of the so-called perturbations of the moon. Another is a movement of the apse line or major axis of the ellipse, which revolves completely in the plane of the moon's orbit in 8·86 years. The phases must always be taken into account, as they show the relative positions of the sun and moon. One phasial cycle is nineteen years, when the phases are repeated within twenty-four hours of the same time. After sixty-two years they are repeated to within a few minutes; therefore, the following periods have to be taken into consideration:

18·6 years (nodal), 8·86 (apsidal),
19 years and 62 years (phasial).

The following are some of the many cycles which are used by Mr. Clements in working out predictions:

$$
\begin{aligned}
186 &= 10 \times 18{\cdot}6 = 21 \times 8{\cdot}86 = 3 \times 62 \\
133 &= 7 \times 19 = 15 \times 8{\cdot}86 \\
130 &= 7 \times 18{\cdot}6 = 10 \times 13 \\
99 &= 10 \times 8 + 19 = 62 + 2 \times 18{\cdot}6 \\
93 &= 3 \times 31 = 10 \times 8 + 13 \\
75 &= 62 + 13 \\
44 &= 31 + 13 \\
31 &= 18 + 13 \\
18 &= 13 + 5 \\
13 &= 18 - 5 \\
5 &= 10 - 5 \text{ and multiples thereof.}
\end{aligned}
$$

After eighteen years the moon's transit, parallax, and declination are almost the same eighteen days earlier and eleven days later respectively. Every thirty-one years (the sum of eighteen and thirteen) the opposite phase of the moon occurs about two days later. Every five years (the difference between eighteen and thirteen) the opposite phase occurs about three weeks later, with a singular relation to the apse, and every ten years the same phase, having the same relation to the apse, occurs about eight weeks later in the year. Every thirteen years the phases recur, rather over a week later, and every twenty-six years the opposite phase and apse occur about the same time.

Due emphasis being given to the foregoing statement it will be made clear how it follows, in accordance with invariable law, that the conjunction of moon and sun at an angle of 45° above any part of the earth causes the part under the influence to become subject to a great 'pull,' which lifts a large portion of the atmosphere from the earth's surface, reducing pressure thereupon, and also upon every particle of the soil within range of the 'pull' and so releases earth-strains and sets free explosive matter, tugging at the leash as it were, to become free. To put this in more close relation to what follows, I repeat some propositions which have already appeared in these pages.[1] They are as follows:

[1] See pp. 52–56, *ante*.

1. In accordance with the law of gravitation the attraction of the moon on each and every particle of the atmosphere, hydrosphere and lithosphere, varies inversely as the square of the distance.

2. Whether on the same or on the opposite side of the earth, there is a large differential attraction between a particle of matter at or near the surface and a particle of matter at the centre of the earth.

3. The moon's horizontal disturbing force upon a particle of matter above whose horizon the moon has risen varies directly as the sine of twice the moon's altitude; when the altitude is 45° the attraction is at a maximum; and from 0° to 45°, and, from 45° to 90° the horizontal disturbing force increases respectively from zero to a maximum, and from a maximum (at 45°) to zero (at 90°).

4. When the moon's horizontal disturbing force acts upon a particle of matter at rest the particle will move in the direction of the force with a gradually increasing velocity, the greatest velocity of the particle being attained when the force ceases to act.

5. If the particle of matter is moving in the opposite direction to that of the horizontal disturbing force, when it begins to act the velocity of the particle will gradually lessen till it is brought to rest, after which the velocity will gradually increase in the direction in which the force acts.

6. If the particle of matter is moving at an obtuse angle to the direction of the horizontal disturbing force, the direction of the motion of the particle will be changed and the velocity of the particle will be lessened.

7. If the angle be right the direction is altered without change of velocity.

8. If the angle be acute the direction of the motion will be changed and the velocity of the particle will be diminished.

9. A particle of matter at rest will not begin to move until the horizontal disturbing force is sufficiently large to overcome friction, and when a gradually diminishing force just equals the force of friction it cannot increase the particle's velocity, but the particle will at that moment have attained its greatest velocity.

In addition it may be stated that earthquakes are not likely to occur when the difference in declination between

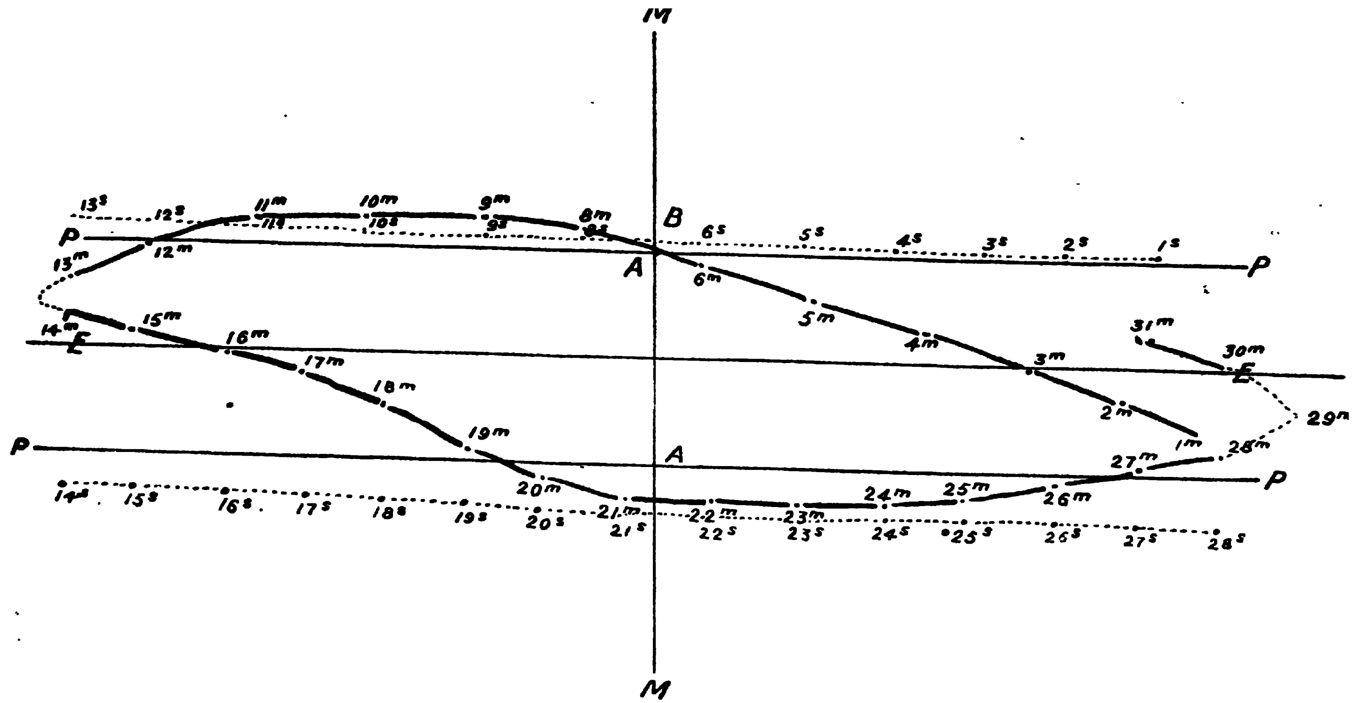


FIG. 2.—THE POSITION OF SUN AND MOON IN RELATION TO MONT PELÉE, MAY 1902.

the moon and sun is 45°, i.e. when the moon is 23° N., and the sun 22° S. or *vice versa*, and also in a lesser degree when the difference is 34, 28, 18, and 7.

If the above propositions are borne in mind the technical statements which follow will be readily grasped even by the non-scientific reader. Put the theory to practical issues, what is the result ? I will begin backwards, and take the destructive earthquake and volcanic eruptions in Martinique first. In order to explain the eruption of Mont Pelée, Mr. Clements prepared the accompanying diagram (Fig. 2).

A denotes the position of Mont Pelée with reference to the equator, E E, this mountain lying about 14° 55′ north latitude and about 61° to the west of the meridian of Greenwich. Taking the sun on the meridian, M M, it was in declination 14° 52′ North, a few minutes south of the mountain, at the beginning of May, and by the end of the month it was 21° 49′, nearly 7° North of the place at B on the meridian.

The eruption commenced on May 3, when the moon, 3^m, crossed the equator at an angle of 45° with the sun, and at the same angle with Mont Pelée at noon. The tangential pull of the moon at that angle was sufficiently great to produce the earthquake that caused the rumbling noises heard on that date, together with the towering flames, and, on the 4th, the heavy fall of ashes. On the 5th there issued a stream of molten lava twenty feet high and half a mile wide caused by the sudden and violent rents and fissures, instantaneous vacuums immediately sucking in water and producing steam on a grand scale of irresistible pressure, so that the lava mass belched forth in enormously large quantities. This was due to Mont Pelée, A, passing, by the earth's rotation, between 5^m, the position of the moon, and 5^s, the position of the sun; and, about the moment when Mont Pelée was at an angle of 45°, from the resultant position of the moon

and sun, the force would be greatest and the lava would be shot upwards to the highest point attained. On the 6th, when Mont Pelée, A, moving along the line P P got quite close between the moon and sun earthquakes occurred incessantly, and the crater belched forth tremendous smoky fumes and lava. On the 7th, when the sun and moon were together over the mountain, the land near the seaboard was violently shaken by earthquakes, with heavy cannonading sounds. All these phenomena, terrible and awe-inspiring though they proved, were but leading up to the great outburst for which, rapidly converging into direct line with each other, the moon and sun were preparing.

On the morning of the 8th, when the moon crossed the sun in declination at 8^m and 8^s, and when the moon was nine hours after new and eleven hours before perigee, these luminaries were pulling together between sunrise and noon at an angle of 45°, when there suddenly sprang up, at the moment when the attraction was greatest, a whirlwind of fire, steam, and boiling mud, enveloping St. Pierre and its roadstead in darkness, death, and ruin. On the 9th, 10th, and 11th the moon and sun kept close together in declination, and within striking distance of A, Mont Pelée, moving along P P so that the crater continued to be active. Between the 11th and 12th the moon crossed the sun in declination, and by the 12th at 4.47 she was (in the afternoon) directly over the mountain, which was active until after the 12th, there being a lull from the 14th to the 18th, when the moon, 14^m to 18^m, was remote from the sun; but on the 19th the moon came close to A, the nadir of Mont Pelée, with the sun, 19^s, close by in nadir position, after which the crater was occasionally active until the 28th at 28^m, when the moon got out of range with the sun and out of the range of the crater, so far as Martinique was concerned, with the exception of recrudescences in

August and September, possibly in November 1902, and February 1903, due to similarity of positions of latitude and lunar and solar declinations. These later manifestations are described on pp. 104–106.

The position may be summarized in these terms:—On May 7 the sun and moon passed the meridian of St. Pierre together. On the 6th and the 8th there was only an interval of half-an-hour in the times at which these luminaries passed the meridian. From these dates the interval increased up to three hours on the 3rd and the 11th when at an angle of 45° with St. Pierre. On the 21st and 22nd the transit interval was under half-an-hour, increasing up to three hours on the 18th and 26th. From the 3rd to the 12th there was only a small interval between the latitude of St. Pierre and the declination of the sun. On the 7th and 8th, and on the 12th and 13th, 20th and 21st, and 26th and 27th, there was only a small difference between the declination of the moon and the latitude of St. Pierre. From the 7th to the 12th, and from the 21st to the 26th, there was but a small difference between the declination of the moon and sun. From all these considerations of transit, parallax, declination of moon and sun, and the latitude of St. Pierre, it can be readily understood that the greatest eruptive effect would be produced on the morning of the 8th; from the relative positions of the moon, sun, and the volcano it follows that all the eruptive actions can be readily accounted for and why they lasted from the 3rd to the 27th of May.

The question may occur to the general reader: May it not have been that this conjunction of moon and sun at a particular angle with regard to Martinique was accidental as it were, or, in other words, a coincidence? 'To establish the connexion between the solar and lunar 'pull' and the destruction in Martinique you would need to show that like combinations in previous times, in the

same region, were accompanied by similar phenomena. The question and the observation are justified, and may be at once answered. Martinique suffered from severe earthquakes in 1657, 1747, 1753, 1756, 1766, 1776, 1779, 1780, 1788, 1813, 1817, 1823, 1825, 1839, 1843, 1851, and 1902. Each of these years was in the same or in a very similar position in the node cycle of the moon of 18·6 years with one or more of the other earthquake years, as will be evident from the following comparison :—

$$
\begin{array}{rcrcrcl}
1843-1657 & = & 186 & = & 10 & \times & 18{\cdot}6 \\
1788-1657 & = & 131 & = & 7 & \times & 18{\cdot}6 \\
1766-1747 & = & 19 & = & 1 & \times & 19 \\
1825-1753 & = & 72 & = & 4 & \times & 18 \\
1813-1756 & = & 57 & = & 3 & \times & 19 \\
1823-1766 & = & 57 & = & 3 & \times & 19 \\
1813-1776 & = & 37 & = & 2 & \times & 18{\cdot}6 \\
1817-1779 & = & 38 & = & 2 & \times & 19 \\
1851-1779 & = & 72 & = & 4 & \times & 18 \\
1817-1780 & = & 37 & = & 2 & \times & 18{\cdot}6 \\
1825-1788 & = & 37 & = & 2 & \times & 18{\cdot}6 \\
1843-1788 & = & 55 & = & 3 & \times & 18{\cdot}6 \\
1851-1813 & = & 38 & = & 2 & \times & 19 \\
1839-1766 & = & 73 & = & 4 & \times & 18{\cdot}6 \text{ nearly} \\
1902-1753 & = & 149 & = & 8 & \times & 18{\cdot}6.
\end{array}
$$

The eruptions of 1753, 1756, and 1902 happened when the declination of the moon was about 19° ; those of 1788 and 1813 when the declination was about 21° ; those of 1657, 1753, 1825, 1843, and 1851 when the declination was about 23° ; while those of 1747, 1766, 1779, 1780, 1817, 1823, and 1839 took place when the declination was about 27°. It may thus be seen that eruptions at Martinique have taken place, and may occur, at any declination of the moon, the time of the occurrence really depending upon the relative position of the sun and the moon with regard to Martinique irrespective of the particular declination or position in the node cycle. Further, the eruptions of 1657, 1747, 1756, 1766, 1776, 1779,

1839, 1813, 1823, and 1843 were at intervals of the ten years' lunar cycle or multiples thereof. 1753, 1766, and 1779 were separated by the lunar cycle of thirteen years. It will also be found that each of the seventeen recorded eruptions since 1657 was connected with each of the other sixteen by one or more of the lunar cycles of 5, 8, 10, 13, 18, 31, 44, 62, 75, 93, 124, 130, 133, or 186 years.

$$
\begin{array}{llll}
1902 - 1657 & = 245 & = 18{\cdot}6 \times 3 + 10 \times 19 \\
1902 - 1747 & = 155 & = 2 \times 62 + 31 \\
1902 - 1753 & = 149 & = 130 + 19 \\
1902 - 1756 & = 146 & = 133 + 13 \\
1902 - 1766 & = 136 & = 186 - 50 \\
1902 - 1776 & = 126 & = 7 \times 18 \\
1902 - 1779 & = 123 & = 133 - 10 \\
1902 - 1780 & = 122 & = 62 + 60 \\
1902 - 1788 & = 114 & = 133 - 19 \\
1902 - 1813 & = 89 & = 70 + 19 \\
1902 - 1817 & = 85 & = 62 + 13 \\
1902 - 1823 & = 79 & = 60 + 19 \\
1902 - 1825 & = 77 & = 3 \times 19 + 20 \\
1902 - 1839 & = 63 & = 13 + 50 \\
1902 - 1843 & = 59 & = 19 + 40 \\
1902 - 1851 & = 51 & = 31 + 20
\end{array}
$$

The eruptions this year (1902) are, therefore, connected with the previous eruptions by intervals of 10, 13, 18·6, 19, or 31 years (all lunar cycles) or multiples thereof. The distinct connexion with each other shows they occur under a general law; had that law been known each could have been predicted, as all phenomena of the like kind may be predicted for the future.

Only by a multitude of instances can the operation of such a law as Mr. Clements has discovered be so demonstrated that it shall enter into the warp and woof of modern knowledge and become a part of our intellectual certitude as, for example, have the laws whereby eclipses and tides are predicted. The reader must, therefore,

EARTHQUAKES AND VOLCANIC ERUPTIONS IN 1902. JANUARY TO JULY.

No.	Date.	Time of Day.	Place.	Lat.	Long.	Upper Transit. Moon. h. m.	Lower Transit. Moon. h. m.	Parallax Upper Transit. Moon. ′ ″	Parallax Lower Transit. Moon. ′ ″	Declination. Upper Transit. Moon. ° ′	Declination. At Time of Earth-quake. Moon. ° ′	Declination. Lower Transit. Moon. ° ′	Declination. Sun. ° ′	Declination differences between Moon and Sun.		Distance in degrees from seat of Earth-quake. Moon.	Distance in degrees from seat of Earth-quake. Sun.
1	Jan. 12		Nova Scotia	45°N	65°W	2·11	14·36	59·31	56·47	9·10S	8·50	7·4S	21·45	12·55	30·35	60°	90°
2	„ 15–16		Croatia	46°N	16°E	4·35	17·0	58·6	58·51	4·27N	5·0N	6·47N	21·3	16·3	26·3	60°	90°
3	„ 15–16		Mexico	25°N	100°W	5·25	17·0 / 17·51	58·37	58·51	8·2N	7·20N	11·10N	21·3	13·43	28.23	60°	90°
4	„ 24		Lisbon	39°N	9°W	13·1	0·35	58·35	58·55	10·47N	—	12·48N	19·20				
5	Feb. 16		Schemachi	41°N	48°E	7·3	19·32	59·15	59·14	19·33N	—	19·38N	12·32				
6	Mar. 13		Ichangerian	?	?	?	?	?	?	?		?	?				
7	„ 29		Lucca	44°	10°E	16·34	4·10	54·22	54·10	19·15S	—	18·55S	3·7				
8	April 18		Guatemala	15°N	90°W	9·7	21·30	56·21	56·6	2·50N	—	0·40N	10·35				
9	May 5–8	8 a.m.	Martinique	15°N	60°W	20·48	8·24	58·34	58·3	0·50N	—	1·25S	15·28				
10	„ 3	4 a.m.	Murcia	38°N	1°W	23·31	11·2	60·53	—	14·11N	—	—	16·20				
11	„ 6		Bordeaux	45°N	½°W	23·31	11·2	60·53	60·38	14·11N	—	12·17N	16·20				
12	„ 10		Mount Redoubt	39°N	77°W	2·35	15·6	60·40	60·23	19·14N	—	18·49N	17·26				
13	„ 12–13		Croatia	46°N	16°E	5·27	17·1 / 17·53	58·22	57·57	12·20N	14·13N	10·25N	18·13	4·0	32·26	60°	90°
14	„ 12–13		Pic di Colima	19°N	104°W	5·27	17·1 / 17·53	58·22	57·57	12·20N	—	10·25N	18·13				
15	„ 18		San Francisco	37°N	123°W	9·21	21·43	54·57	54·45	8·23S	—	10·12S	19·24				
16	„ 20		Florida	27°N	82°W	10·51	23·14	54·17	54·11	14·52S	—	16·9S	19·50				
17	„ 22		Creusot	46°N	4°E	12·24	0·1	53·59	54·2	18·42S	—	18·3S	20·15				
18	„ 28		Cape Peninsula	35°S	18°E	17·7	4·44	55·41	55·24	9·35S	—	11·23S	21·21				
19	„ 28		Greece	38°N	23°E	17·7	4·44	55·46	55·24	9·35S	—	11·23S	21·21				
20	June 3		Villetri	42°N	13°E	22·11	9·42	60·51	60·33	15·45N	—	14·5N	22·13				
21	„ 3		Baku	41°N	48°E	22·11	9·42	60·51	60·33	15·45N	—	14·5N	22·13				
22	„ 4		Chaco	42°S	73°W	23·12	10·41	61·16	61·6	18·14N	—	17·9N	22·21				
23	„ 8–9		Cheshire	53°N	2°W	2·19 / 3·17	14·49 / 15·44	59·40	60·5 / 59·13	13·58N	14·57N	15·40 / 12·9N	22·52	7·55	37·49	90°	60°
24	„ 12		St. Vincent	13°N	61°W	5·49	18·12	56·50	56·25	1·27N	—	0·35S	23·6				
25	„ 14		Sicily	37½°N	15°E	7·20	19·42	55·21	55·2	7·2N	—	8·56S	23·14				
26	„ 18		Himalayas.	30°N	85°E	10·22	22·45	54·1	53·59	18·17S	—	18·51S	23·23				
27	July 5		Salonica	41°N	23°E	24·0	12·30 / 11·29	60·59	60·48 / 61·5	18·11N	—	17·7N / 18·33N	22·51				
28	„ 7–8		Cheadle	53½°N	2¼°W	2·51	14·25 / 15·17	58·55	58·27	8·0N	9·20N	10·10N / 5·50N	22·33	13·13	31·53	90°	60°
29	„ 9		Bandar Abbas	27°N	56°E	3·41	15·17 / 16·6	57·37	57·39	3·30N	5·0N	1·15N	22·27			75°	60°

pardon an accumulation of evidence, in which details are necessarily repeated and the same mode of reasoning is adopted, while a like kind of example is again and again submitted. Only by the accumulation of many instances can the general law be established.

Shocks and Eruptions at Fort de France, Martinique, on July 9, from 7.30 p.m. to Midnight.

When the moon was on the meridian of Fort de France the sun was at 3h. 41m. (Fig. 3), and when it was at A,

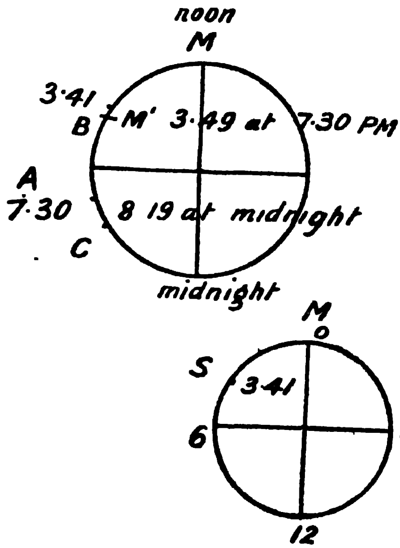


Fig. 3.

7h. 30m., when the shocks commenced, the moon was at 3.49 (B), the moon at that time being about 60° from Fort de France, while the sun was about 90° distant. When it was midnight the moon was at C, 8h. 19m., or 3h. 41m. before midnight. The moon, when the shock commenced, was 3h. 49m. after noon, and when the shocks ceased she was 3h. 41m. before midnight at

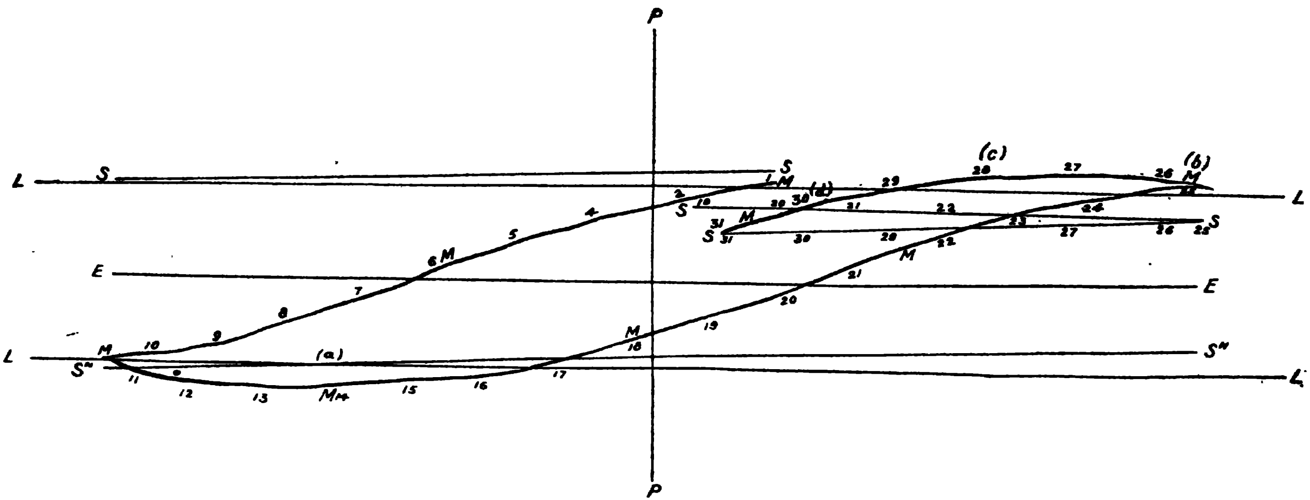


FIG. 4.

Graphic representation illustrative of the course of the moon and sun during August 1902 with reference to the latitude and meridian of the Lesser Antilles, and demonstrative of the fact that the activity of Mont Pelée and other volcanoes in that region was dependent upon the proximity of the latitude with declinations of the moon and sun.

(*a*) Eruptions of Mont Pelée commenced on the 14th, when nadir sun crossed nadir latitude with the moon near at M 14. (*b*) Eruptions on August 25 to 26, with enormous fall of ashes, the moon being a little north, with the sun a little south of Mont Pelée; (*c*) On 28th there was a very severe eruption with the moon just north, and the sun south of Mont Pelée; (*d*) On the 30th there was the severest eruption, with the moon midway between the latitude of Mont Pelée and the declination of the sun, and loud detonations at Soufrière, St. Vincent.

the same relative angle with the meridian and ante-meridian of Fort de France.

The disturbances in the Antilles were renewed early in July and in the latter days of August and the earlier part of September. If there were truth in the Clementian theory this was as it should be. A few days after the earlier outbreak Mr. Clements informed the present writer that a recrudescence of the disasters might be expected, owing to the position which the sun, moon, and earth would occupy towards the affected islands on their return to a position similar to that of May. The diagram (Fig. 4) on the preceding page will, with the explanation that follows, make clear the *rationale* of the second series of outbursts.

In the diagram PP denotes the meridian of Mont Pelée; LL and L′L′ represent the latitude and nadir latitude respectively of Mont Pelée; EE, the equator; S^N and S^N the sun's nadir course; S S the sun's actual course; and M M, the moon's actual course, the dates being given for the month of August 1902, along the course from 1st to 31st.

From the diagram it will be observed that the nadir latitude of the Antilles L′L′, the nadir sun S^NS^N, and the moon's course from the 10th to 18th are in proximity, and that from the 22nd to the 31st of August the course of the moon and sun at the latitude of the Antilles are also in proximity; the tidal effect upon the subterranean lavas and gases would be great and would culminate about the 11th, 17th, 25th and 30th, but really would be continuous from 10th to 18th and 22nd to end of the month. The moon, sun, and Martinique were in close proximity on August 1st, but as the moon rapidly retired from 2nd to 9th, no lasting effect was produced, and from 19th to 21st the moon was remote from the sun and the latitude of St. Pierre; no effect was produced. The reason why the eruptions at Martinique were chiefly

confined to May and August was that the sun's declinations were approximately alike during those months, and the moon in part of her course was in close proximity to both the latitude of the Antilles and the declination of the sun. It was during this close proximity that all the recent eruptions and earthquakes occurred.

If the fifty-seven earthquakes (*see* pp. 108–109) that have occurred in the United Kingdom since 1882 be carefully examined it will be found that the times at which they take place vary; in other words the sun may be in any position from sunrise to sunset or from sunset to sunrise. The moon also may be in any part of its orbit. She may be in any declination from zero to 28½° north or south of the equator, and she may be also at any distance from the earth within the limits of apogee and perigee.

At first sight it might seem that any attempt to obtain order and law out of what appears to be an arbitrary condition of things would be quite hopeless. On further examination, however, it will be found that the time of the moon's transit or crossing of the meridian of the place where the earthquake occurs is an essential feature in each case. In fact the time of the moon's transit is most important.

Let this be borne in mind, and it will be seen that each of the fifty-seven recorded British earthquakes took place either when the moon transited the meridian or antemeridian about noon or midnight, at three o'clock in the afternoon or morning, or nine o'clock at night or in the morning, or about six o'clock in the evening or morning.

In other words, an earthquake always takes place when the angular distance between the moon and sun is 0° or 180° (0 hours or twelve hours apart), 45° or three hours, and 90° or six hours. When the sun and moon are together at new moon at 0° or 0 hours' interval or opposite at full moon at 180° or twelve hours' interval, these luminaries are pulling together and causing a great tidal

THE RECORD OF FIFTY-SEVEN BRITISH EARTHQUAKES.

		Date.	Transit.	Parallax.	Declination.		Difference.		Nearest Lunar angle with Sun.
					Moon.	Sun.			
1	Knighton	31/5 82	14·46	57·12	20·5S	21·56N	1·51	42·1	45°
2	Comrie	30/9/82	14·23	58·47	19·22N	2·52S	16·30	22·14	45°
3	Clifton Hastings Monmouth Abergavenny	16/1/83	6·30	58·48	14·22N	20·56S	6·34	35·18	90°
4	Taunton	23/1/83	12·41	55·31	12·18N	19·27S	7·9	31·45	0°
5	Shropshire	26/1/83	14·53	54·21	0·21S	18·43S	18·22	19·4	45°
6	Launceston	24/6 83	15·44	58·18	7·20S	23·25	16·5	30·45	45°
7	Bournemouth	21/10/83	17·19	57·40	17·5N	11·2S	6·3	28·7	90°
8	Colchester	22/4/84	22·1	59·55	2·52N	12·25N	9·33	15·17	45°
9	Clitheroe	14/11/84	22·5	54·53	9·27S	17·4S	7·37	26·31	45°
10	Taunton	23/1/85	5·41	58·6	9·33N	19·19S	9·46	28·42	90°
11	Colchester	25/1 85	7·29	59·32	15·59N	18·50S	2·51	34·49	90°
12	Yorkshire	18/6/85	5·22	58·13	4·6N	23·25N	19·19	27·31	90°
13	Gateshead	3/12/85	22·13	55·58	13·12S	22·10S	8·58	35·22	45°
14	Bodmin	20/1/86	12·50	61·26	14·31N	20·4S	5·33	34·35	0°
15	Gorebridge	8/4/86	3·19	57·38	16·29N	7·16N	9·13	23·45	45°
16	Comrie	18/4/86	12·24	58·32	9·12S	10·53N	1·41	20·5	0°
17	Garelochhead	15/5/86	10·15	58·15	7·26S	18·54N	11·28	26·20	0°
18	Guernsey	7/6/86	4·45	59·34	11·45N	22·46N	11·1	34·31	90°
19	Kilsyth	14/8/86	12·13	53·59	12·11S	14·19N	2·8	26·30	0°
20	Jersey	20/4/87	22·45	54·17	1·12N	12·0N	10·48	13·2	0°
21	Rhondda Valley	12/10/87	20·42	59·44	12·30N	7·58S	4·32	20·28	45°
22	Leeds	3/11/87	14·13	55·4	18·28N	15·33S	2·55	34·1	45°
23	Herts	20/11/87	4·44	56·24	16·47S	19·49S	3·2	36·36	90°
24	Chorley	30/12/87	12·9	55·10	17·52N	21·54S	4·2	39·46	0°
25	Edinburgh	29/1/88	13·10	58·44	14·48N	17·43S	2·55	32·31	0°
26	Edinburgh	17/1/89	12·50	55·30	19·45N	20·26S	0·41	40·11	0°
27	Bolton	10/2/89	8·12	54·21	20·51N	14·10S	6·41	35·1	45°
28	Guernsey Bournemouth Isle of Wight Portsmouth	30/5/89	0·35	53·58	20·41N	21·50N	1·9	42·31	0°

		Time.	Date.	Transit.	Parallax.	Declination.		Difference.		Nearest Lunar angle with Sun.	Distance at Moment of Shock.		Total.
						Moon.	Sun.				Moon.	Sun.	
29	Rhondda Valley . .		21/6/89	19·35	55·45	2·21N	23·26	21·5	25·47	90°			
30	Guernsey . .		9/7/89	9·5	60·27	18·0S	22·19N	4·19	40·19	45°			
31	Camelford . .		7/10/89	11·5	57·37	4·0S	5·40S	1·40	9·40	0°			
32	Perthshire . .		6/1/90	12·45	53·58	23·3N	22·28S	0·35	45·31	0°			
33	Chelmsford . .		7/1/90	13·33	54·4	21·17N	22·20S	1·3	43·37	0°			
34	Wetherby . .		25/6/90	6·16	55·35	2·18N	23·24N	21·6	25·42	90°			
35	Beauly . . .		15/11/90	2·29	58·48	24·59S	18·33S	6·26	43·32	45°			
36	Ness . . .		1/12/90	16·28	54·18	20·57N	21·51S	0·54	42·48	45°			
37	Boscastle . . Surrey . . .		26/3/91	13·13	54·45	5·45S	2·12N	3·33	7·59	0°			
38	West of England .		17/8/92	20·36	58·0	27·25N	13·12N	14·13	40·37	45°			
39	Severn . . .		3/1/93	13·35	58·57	24·9N	22·46S	1·23	46·55	0°			
40	Isle of Man . .		5/5/93	15·59	54·31	27·54S	16·23N	11·31	44·17	45°			
41	Leicester . Eastbourne .	6.30 p.m.	4/8/93	17·47	59·0	15·9N	17·7N	1·58	32·16	90°	67°	83°	150°
42	South of Wales Cornwall .	5.45 p.m.	2/11/93	20·4	57·4	10·30N	14·55S	4·25	25·23	45°	81°	75°	156°
43	Shepton Mallet .	11.30 p.m.	30/12/93	18·52	55·31	8·45S	23·8S	14·23	31·53	90°	86°	75°	161°
44	Lynton . . .	9 a.m.	24/1/94	16·3	57·29	2·59N	18·53S	15·54	21·52	45°	80°	80°	160°
45	Pontypridd . .	3 a.m.	10/4/94	3·57	59·23	28·29N	8·17N	20·12	36·46	45°	83°	62°	145°
46	South Wales . .		6/5/94	0·43	59·54	23·25N	16·36N	6·49	40·1	0°			
47	Dumfries . .		14/5/94	8·19	57·33	2·24N	18·41N	16·17	21·5	45°			
48	Comrie . . .	10.45 and 11.30 p.m.	12/7/94	8·1	55·5	23·0S	21·57N	1·3	44·47	45°	88° 90°	80° 78°	168° 168°
49	Comrie . . .		12/7/95	16·30	54·22	0·42N	21·59N	21·17	22·41	90°			
50	Annandale . .	4.45 a.m.	29/5/96	14·2	58·4	27·2S	21·44N	5·18	48·46	45°	90°	62°	152°
51	Rhondda Valley .	11 p.m.	15/10/96	7·46	55·25	14·55S	8·48S	6·7	23·43	90°	80°	62°	142°
52	Hereford . .	5.35 a.m.	17/12/96	10·3	54·40	23·20N	23·24S	0·4	46·44	45°	90°	67°	157°
53	Rathmore (Bog) .		27/12/96	18·27	59·16	10·55S	23·18S	12·23	34·13	90°			
54	Kilsyth . . .		7/1/98	12·7	54·33	23·8N	22·20S	0·48	45·28	0°			
55	Comrie . . .		28/8/98	9·38	60·13	19·5S	9·37N	9·28	28·42	45°			
56	Wrexham . .		22/1/01	1·48	59·17	7·31S	19·46S	12·15	27·17	45°			
57	Ambleside . .		9/7/01	18·49	59·27	13·52N	22·25N	8·23	36·17	90°			

effect upon particles of air, water, and earth-crust; these bodies are then either together or opposite at an angle of 45° with the horizon or meridian of the particular particles. The horizontal disturbing force of the moon has no appreciable effect at 0° or 90°, and the force that has been gradually increasing from 0° to 45° attains its maximum 'pull' or strain on a particle of air, water, or earth when the force ceases at or before the distance between the moon or the sun reaches 90°.

The earthquake at Hereford on December 17, 1896, took place near the time of full moon when the sun and moon

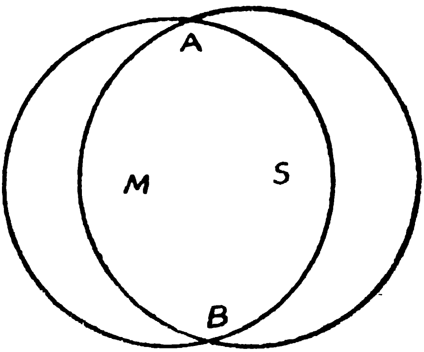


FIG. 5.

were at an angle of less than 45°, as in the figure, the circles at the angle from the points on the earth's surface directly underneath cut at the points A and B, where the pulling force of these luminaries is at a maximum; and after increasing up to not less than 60° or more than 90° from those parts of the earth's surface A or B would cause an earthquake provided that the crust conditions were favourable.

Again, when the sun and moon are at an angle of 90°, they would pull with their maximum force at an angle of 45° from each at the point C, where an earthquake would be produced, provided conditions were favourable —that is to say, they would do this after the lapse of from

one to three hours to permit the lunar and solar force to increase sufficiently.

Of the earthquakes that took place when the moon transited the meridian near noon or midnight, there is a very close similarity between Nos. 4 and 14 on the list; and also between 14 and 46; Nos. 22, 24, 25, and 37; 17, 20, and 50; and between 1, 16, 19, 26, 28, 31, 32, 33, 39, 52, and 54.

Of the earthquakes that took place at A and B (Fig. 5) at an angle of about 45° between the sun and moon's transit about three hours before or after noon or midnight, Nos. 18 and 40 are alike; so are 15 and 55; 38 and 47; 2 and 5; 6 and 44; 8, 9, 13, 20, and 55; and 11, 21, 30, 35, 42, and 50.

Of the earthquakes that occurred at or near C (Fig. 6) when the sun and moon were about 90° apart, or when the moon transited the meridian or anti-meridian about

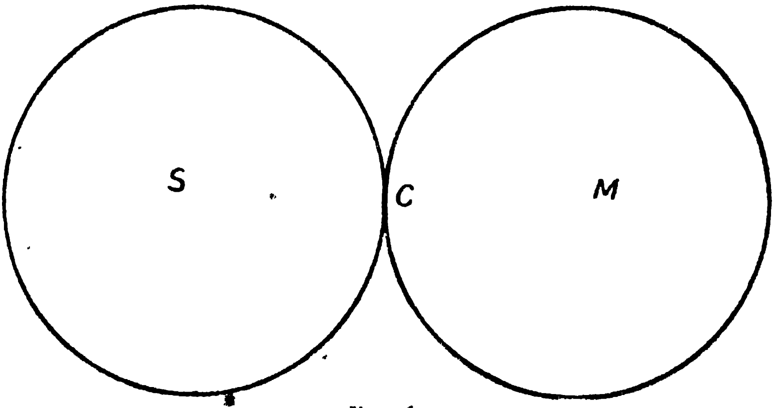


FIG. 6.

sunrise or sunset, Nos. 11 and 23 were alike; so were 10 and 57; 43 and 53; 36 and 41; 12, 45, and 49; 29, 34, 45, and 48; and also 3, 7, 27, and 51. I will compare any two of these earthquakes—say, No. 8 (Colchester) and No. 20 (Jersey).

		Transit.	Parallax.	Moon Dec.	Sun Dec.	Difference	
Colchester	22/4/84	21·1	59·55	2°52′n	12°25n	9°33	15°17
Jersey ...	20/4/87	22·45	54·17	1°12′′n	12°0n	10°48	13°2

Here, observe that the time of transit is nearly the same, that the moon's and the sun's declinations are nearly the same, and also the difference.

Hereford.

I will go more minutely into detail and take the earthquake which occurred at Hereford on the morning of De-

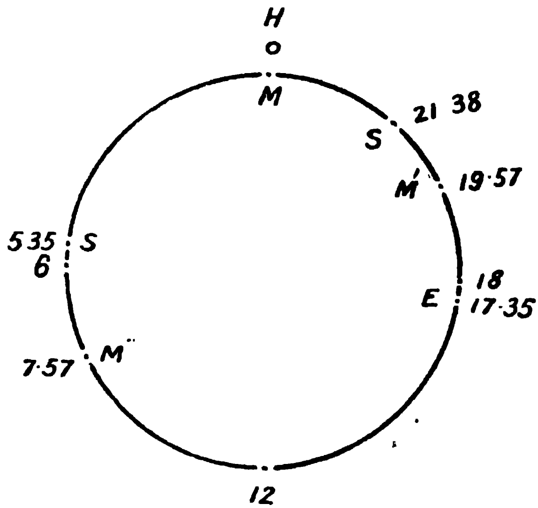


Fig. 7.

cember 17, 1896, at 5h. 35m., or on the 16th, at 17h. 35m. astronomical time, as indicated on Fig 7. Let H denote the meridian of Hereford, over which the moon was on the 16th about 21h. 38m., while point S indicated the position of the sun relative to the moon at M. In order to obtain the position of the moon at the time of the earthquake it is necessary to move the sun backwards from S to E, or through a space of 4h. 3m.; of course we shall have to move the moon also backwards from M to M′

by the same interval, so that M′ and E would represent the actual positions of the moon and sun at the time of the earthquake at a distance of 2h. 22m. As the sun was on the ecliptic south of the equator the nadir sun would move along the ecliptic at S′ not far from the moon at M″ 90° from Hereford while the sun was at 67°; therefore the horizontal disturbing force of the moon increases from 45°, attaining its maximum about 90° from Hereford, just when the disturbing force ceases.

Calcutta and Hereford.

For the purpose of comparison the earthquake that occurred at Calcutta just six lunations of 29½ days, or 177

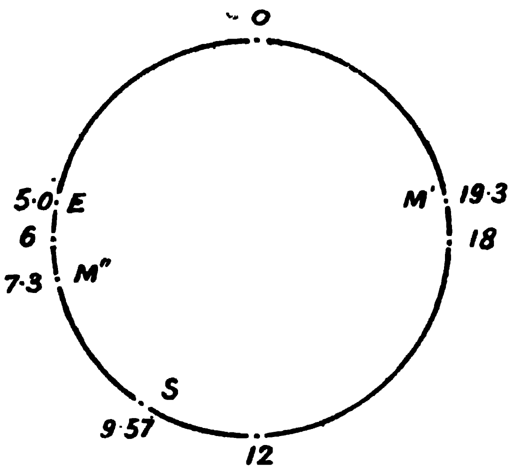


Fig. 8.

days, after the Hereford earthquake, may be taken; the positions of the sun and moon on the ecliptic were then reversed. The moon was in the meridian of Calcutta on June 12, 1897, at 9h. 57m., about twelve hours earlier than 21h. 38m., the time of the Hereford earthquake. The earthquake occurred at Calcutta about five o'clock in the evening (Hereford about five o'clock in the morning).

We have to move the sun backwards through 4h. 57m. to E and the moon backwards through the same space from M to M′ at 19h. 3m., and, as the moon was south, the nadir tide at 7h. 3m., M″, would go round the ecliptic about 2h. from the sun at E 5h. 0m.; the angular distance of the moon and sun from Calcutta at the time of the earthquake was the same, namely, 90° and 67° for the moon and sun respectively.

	Time of Earthquake.	Transit.	Position of Moon.	Moon Dec.	Sun Dec.	Moon from place.	Sun from place.
Hereford	5.35 a.m.	$21^h\,38^m$	$7^h\,57^m$	23°20′N	23°23′S	90°	67°
Calcutta	5.0 p.m.	9.57	7·3	22°53′S	23°11′N	90°	67°

LYNTON.

At Lynton an earthquake shock was felt at nine o'clock in the morning of January 25, 1894, or at 21h. 0m., E,

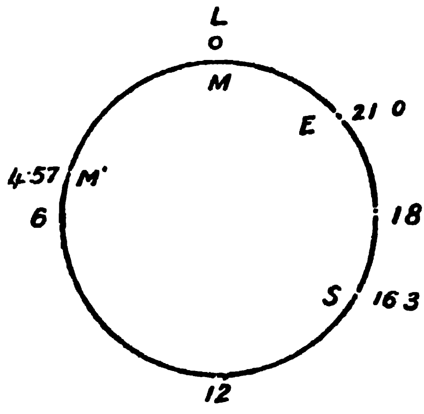


FIG. 9.

astronomical time on the 24th. On the 25th, when the moon was on the meridian at Lynton, L, the sun was at S 16·3. To come up to the time of the earthquake the sun has to be moved forward to E, 21h. 0m., or 4h. 57m., which necessitates the moon being moved forward from M to M′ 4h. 57m. Now M′ and E localize the position of the moon and sun respectively with reference to the meridian of Lynton, the moon and the sun being approxi-

mately 80° in angular distance from that place. In each case the horizontal disturbing force of these luminaries would be greatest at an angle of 45°, but would continue to increase up to the angle of 80°, when there was sufficient accumulated force to put a strain on the strata enough to cause the shock that was experienced.

RHONDDA VALLEY.

In the Rhondda Valley an earthquake occurred on October 15, 1896, at 11 o'clock at night, E, the sun being at 7h. 46m. when the moon was on the meridian oh. at Rhondda. In this case the earthquake took place 3h. 14m. after the moon was on the meridian of Rhondda

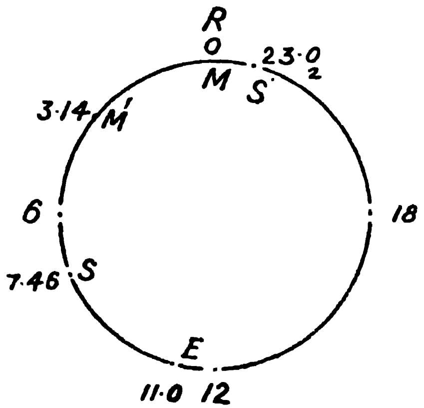


FIG. 10.

at M′ the nadir sun being at 23h. S′. The moon under these conditions was at an angular distance of 80°, and the sun 62° from Rhondda Valley at the time of the earthquake.

ANNANDALE.

At Annandale the earthquake occurred on the morning of May 29, 1896, at 4h. 45m. or at 16h. 45m. astronomical time on the 28th. When the moon was on the meridian of Annandale the sun was at 14h. 2m., and

had to go on for 2h. 43m. before the earthquake occurred, and during this time the moon would move on

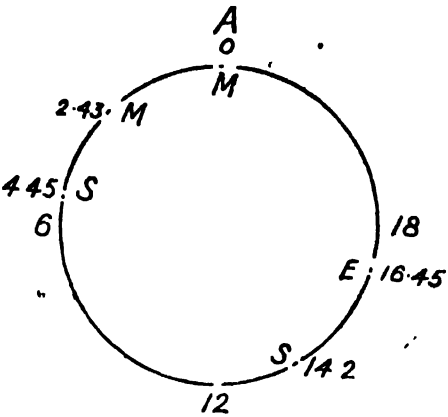


FIG. 11.

to M′ 2h. 43m., the nadir sun being at 4h. 45m. Under these circumstances the earthquake occurred when the moon was about 90° and the sun about 62° from Annandale.

COMRIE:

At Comrie an earthquake shock was felt at 10h. 45m.

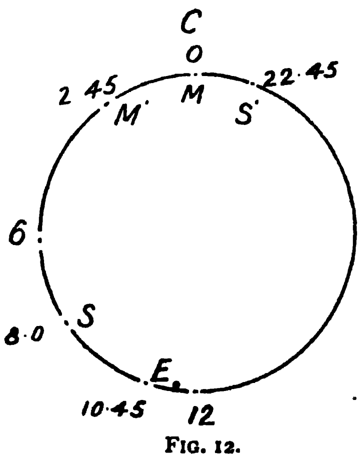


FIG. 12.

at night on July 12, 1894, the moon being on the meridian

when the sun was at 8.0. In this case the moon would be at M′ 2h. 45m. when the earthquake happened, the nadir sun being at S′ 22h. 45m.

The moon was about 88°, the nadir sun being about 80° from Comrie. The latitude of the moon was 23° 0′ S., and that of the sun 21° 57′ N.

There was a second earthquake at Comrie at 11h. 30m. on the same night, the moon being at M′ 3h. 30m., and the nadir sun being at 23h. 30m. The declination of the moon and sun being practically unchanged during

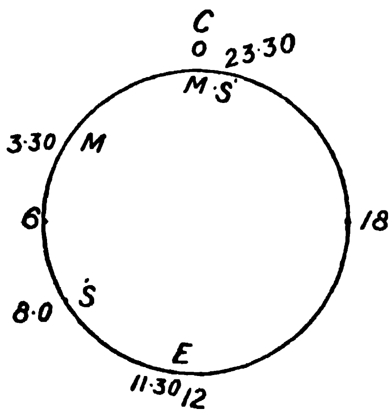


FIG. 13.

the interval of 45 m., the moon was 90° and the nadir sun 78° from Comrie. The shocks occurred in each case when the sum of the distance, 168°, was alike.

PONTYPRIDD.

At Pontypridd an earthquake took place on April 10, 1894, at 15h. astronomical time, the moon crossing the lower meridian when the sun was at 16h. 28m. In these circumstances the moon would be at 10h. 32m. M′ when the earthquake happened. The declination of the moon at 15h. on April 10 was 28° 30′ N., and the nadir moon

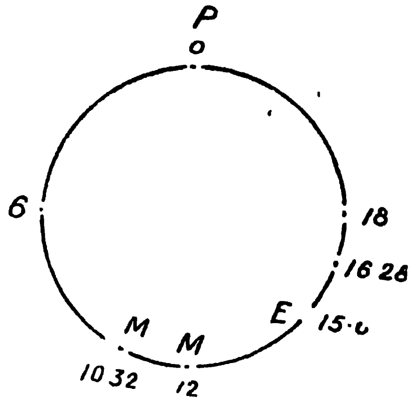


Fig. 14.

of course 28° 30′ S., was 83° and the sun 62° from Pontypridd.

Shepton Mallet:

At Shepton Mallet an earthquake occurred on December 30, 1893, at 11.30 p.m., the sun being at 18h. 52m. S. when the moon was on the meridian. At the time of

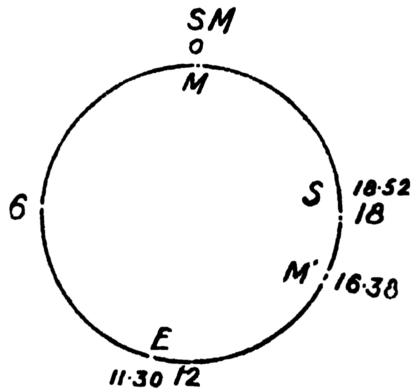


Fig. 15.

the earthquake the moon was at M′ 16h. 38m. and 86° from Shepton Mallet, the sun being 75° therefrom.

SOUTH WALES AND CORNWALL.

An earthquake happened in South Wales and Cornwall on November 2, 1893, at 5.45 p.m., and the lower transit of the moon occurred at S. 7h. 40m. The moon was at 10·5, and the nadir moon at 22h. 5m. As the declination of the moon was 13° 56′ N., and that of the sun 14° 55′ S., these luminaries were respectively at 81° and 75°.

LEICESTER AND EASTBOURNE.

At Leicester and Eastbourne an earthquake took place on August 4, 1893, when the nadir moon was at M″ 1h. 9m., and the sun was at 6h. 30m. The moon was in declina-

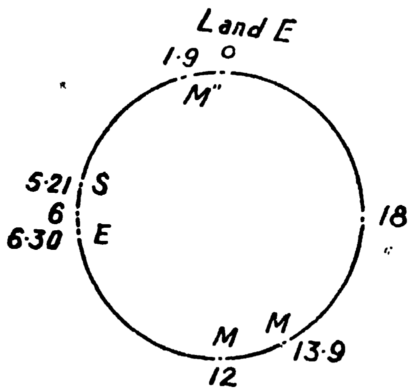


FIG. 16.

tion 15° 9′ N., and the sun 17° 8′ N., and were respectively about 67° and 83° from the seats of the shocks.

It would thus appear from a study of the earthquakes that have happened in Great Britain in the period named, the exact time of which has been given, that, for a shock to take place, the moon or sun must be upwards of 60° and not exceed 90° from the seat of the earthquake, the sum of the distances of these two luminaries averag-

ing about 150° and not exceeding 170° nor less than 140°.

Inverness.

On the morning of September 18, 1901, the sun was in Dec. 2° 13′ N., and the moon was 17° 34′ S. The moon passed the anti-meridian at thirty-six minutes past three o'clock in the morning, and as the earthquake is alleged to have taken place at 1.25 a.m. it occurred 2h. 11m. before the lower meridian passage of the moon in the southern hemisphere. Otherwise the moon was in the zenith of a point on the Pacific Ocean to the north-east of Australia, the nadir point not far from Berber on the Nile, 37° west of the meridian of Inverness, and 45° in the angular distance—the angle at which the moon has the greatest pulling or tidal effect upon the earth's surface—and it was this maximum and instantaneous lifting pull of the moon at an angle of 45° from its nadir position in Egypt that was the immediate cause of the earthquake at Inverness.

In the diagram (Fig. 17), we take I to represent the position of Inverness, M will represent the nadir position of the moon on the earth's surface on the 18th inst., at the time of the earthquake, and S the nadir position of the sun, while M′ will represent the position (nadir) of the moon at the time of the earthquake on September 17, 1801, and S′ the zenith position of the sun just one hundred years and fourteen and a half hours earlier. With regard to these two earthquakes, the moon in both cases was in the southern hemisphere overhead at a considerable distance south from the equator E E, and on opposite sides of the anti-meridian of Inverness, so that their nadir positions at the time of the earthquakes were at M and M′ respectively, and the earthquake did not really happen and could not happen until the nadir moon got at the proper angle

from the meridian I, to be exactly in the angular curve of 45° drawn from I as centre. The moon in 1901 being 27° from the equator had to swing round further from the meridian than the moon in 1901 (about 10° nearer the equator E E), until it got at the correct angular distances. The sun in both cases was 2° from the equator, but so placed that the angular distance S I in 1901 was greater than the angular distance S′ I in 1801, so that there was a greater amount of attractive force

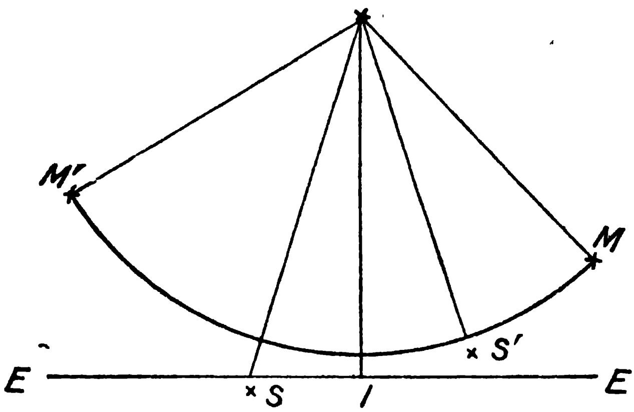


FIG. 17.

on the part of the sun in 1901 than in 1801—3° against 7°—and hence the latter earthquake was more severe.

THE EARTHQUAKE IN ASSAM IN 1897.

The arguments employed above will, perhaps, be better appreciated by a more detailed comparison than has been given already (p. 112) of two earthquakes in different parts of the world at an interval of a little less than six months. On December 17, 1896, an earthquake occurred in England; on June 12, 1897, there happened the great earthquake which caused much

devastation in Eastern Bengal, particularly in Assam, and known as the Calcutta earthquake.

One hundred and seventy-seven days elapsed between the first mentioned date and June 12, 1897, or exactly six complete lunations of twenty-nine and a half days. During the intervening period the sun had completely changed its position from its greatest declination south to its greatest north, i.e. from 23° 23′ S. to 23° 12′ N., while the moon had also reversed its position from 23° 20′ N. to 23° 28′ S. In both instances the time was near to full moon. The hours of the moon's transits were practically the same, and the interval between the earthquake and the full moon was also, for all practical purposes, identical. There was a difference of 90° in the longitude of Hereford and Calcutta, and about 30° difference in the latitude.

		Lat.	Long.	Full Moon.	Earth-quake.	Tran-sit.	Paral-lax.	Moon Dec.	Sun Dec.
Calcutta	12/6/97	22°35′N	88°E	14°9	12.5	9.57	60′55″	23°21′S	23°12′N
Hereford	17/12/96	52°15′N	2°W	19.16	16.17½	10.3	54′27″	23°20′N	23°23′S

The moon being in perigee would account for the more destructive nature of the earthquake in Eastern Bengal. In each case the earthquake took place about two days before the time of full moon. At full moon the intervals between these luminaries is exactly twelve hours or 180°. The true interval between the sun and moon at the times of the earthquakes was as nearly as possible nine hours and fifty-three minutes, which, added to five o'clock in the evening, gives 14.53 hours for the relative position of the moon. At the time of the earthquake the moon passed the anti-meridian 2.53h. previously, and the nadir moon passed the meridian of Calcutta 2.53h. Taking 15° for an hour the nadir moon was at 43° to the west of Calcutta, or nearly 45°. The moon coming up at that angle intensified the tidal effect

the sun had already made, so that the combined pull of the luminaries became irresistible.

The Hereford earthquake took place at 5.35 on the morning of December 17, 1896, or at 17.35h. astronomical time on the 16th; that is to say the nadir sun was 5.35h. astronomical time. As the moon was 9.35h. in advance of the sun, we have, adding to 5h. 35m. the position of the moon as 15.28h. or 3.28h., and by allowing 15° per hour we have the moon as 52° west of the meridian of Greenwich, or 50° west of Hereford when the earthquake took place.

With regard to time and position, these earthquakes occurred as follows:

Earthquake.		h.m.	h.m.	Difference.	h.m.
Hereford	17/12/96	5.35 a.m.	3.28 52° moon.	5.35 p.m. nadir sun.	2.7
Calcutta	12/6/97	5.0 p.m.	2.53 43° nadir moon.	5.0 p.m. sun.	2.7

In 5.35h. the extra 35 minutes are equal to 9°, and 52° less by 9° equals 43°, otherwise 53° moon and 84° sun, equal in effect 43° moon and 75° sun.

There is thus a remarkable agreement in every particular of the circumstances under which these two earthquakes occurred. The difference between the position of the moon and the sun in each case was 2.7h., thus 5h. 35m.—3h. 28m. = 5h. 0m. – 2h. 53m.

Further, an angle of 45° from Hereford cut the parallel of 23½° north, the declination of the moon. At the time of the Hereford earthquake the scientific opinion which found expression was that the disturbance had its origin in the displacement of rocky strata, and the sound which accompanied the disturbance proceeded from the grating of stony surfaces. Whatever part displacement may have played, the disturbance itself was caused by the combined action of the moon and sun exerted over Hereford at an angle of 45° or thereabouts.

With respect to the Calcutta earthquake the *rationale* of the combining causes will be made clear by an examination of the following diagrams :

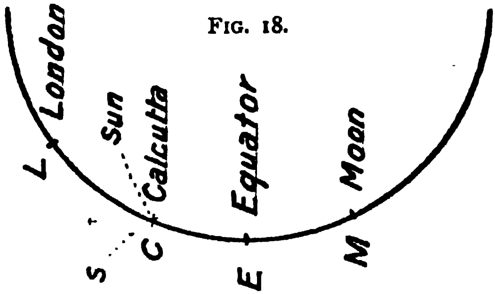


FIG. 18.

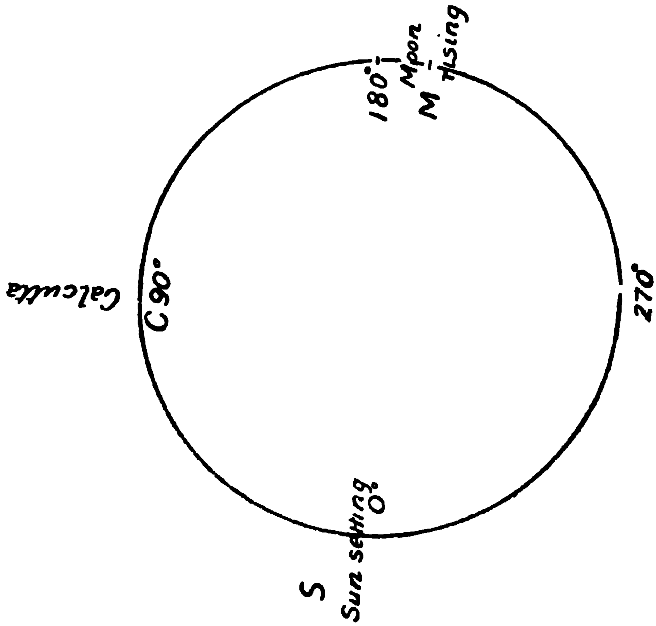


FIG. 19.

In Fig. 19 the position in longitude is shown at the time of the earthquake, S denoting the position of the sun before setting, M the moon before rising, the position of the resultant effect of moon and sun being at 45° from C, the position of Calcutta. In Fig. 18 (see top of page)

the position with regard to latitude is given: M denoting the position of the moon about 23° S., while C stands for Calcutta, 22° N., being about 45° from the moon's position. S gives the position of the sun in latitude near Calculta; E shows the relative position of the equator, and L that of London.

It will be remembered that it is at an angle of 45° that the moon produces its greatest tidal or differential attractive effect, so that the lunar pull, as the moon was almost at its nearest point to the earth, was enormous; at the same time it should not be overlooked that the sun was, as nearly as possible, in the latitude of Calcutta. But this is not all, for, at the time of the earthquake the sun was nearly setting and was about as much above the horizon as the moon was below, so that these bodies were nearly opposite, and about 180° apart.

Calcutta, therefore, at the moment of the shock was situated at the point where the greatest longitudinal and latitudinal lines of resultant luni-solar force centred. The sun was the same distance north of the Equator as the moon was south, and they were about 180° in longitude apart, the sun nearly setting, while the moon was nearly rising, being most favourably placed for producing the greatest seismal effect in Bengal. The earthquake at Hereford occurred under similar circumstances; the moon was at its greatest distance north, while the sun was furthest south; the moon set shortly before the sun rose, but they were in the reverse positions.

The earthquake which occurred at Shillong, in Assam, long. 92° E., and 25½° N. lat., took place at four o'clock in the morning of July 5, 1901. The position of the moon and sun was similar to that on the occasions of the earthquakes in Great Britain, at Launceston, on June 24, 1883, at Gateshead, December 2, 1885, at Shepton Mallet, December 30, 1893, and at Comrie, July 11, 1895.

In brief, the moon, sun and earth on July 13, 1764, and on June 12, 1897, were in absolutely the same relative positions with respect to each other at the moment the earthquake shocks took place, with results almost identically alike in their disastrousness.

The earthquakes in Great Britain, extending over a period of fifteen years, have been considered. It has been shown in every case that these earthquakes occurred at the moment when the resultant of the combined 'pulling' power of the moon and sun was at an angular distance of half a right angle, at which angle common scientific knowledge is aware that their attractive force is greatest. It has been demonstrated that this position for both longitude and latitude and also by great circular measurement from the point of the earth's surface directly under the moon to the point similarly situated under the sun, and showing, especially in the cases of the two most recent disastrous earthquakes in India and England, that the resultant point of their combined tidal action was 45° from the seat of both earthquakes. Mr. Clements has no hesitation in asserting that this law applies to all the earthquakes that have occurred in every part of the world where earthquakes occur or have occurred. The determining force in these respects is a special exercise of that power of attraction or gravitation, which, normally exercised, is the foundation of everything terrestrial that makes human existence possible. In addition to those cited in these pages a great many earthquakes in all parts of the world have been examined by Mr. Clements. Without exception they have happened at any angular distance of 45° from the point where the resultant attraction of the moon and sun was located at the time.

EARTHQUAKES OCCURRING UNDER SIMILAR CONDITIONS OF TRANSIT AND LUNAR AND SOLAR DECLINATION, CORRESPONDING SHOCKS MARKED BY SIMILAR LETTERS a, b, c, ETC.

No.	Transit.	Moon Dec.	Sun Dec.	Diff. of Dec.	
		° ′	° ′		
1	(*a*) 2·11	8·50S *a*	21·45 *a*	12·55 *a*	1, 28, 15
2	(*b*) 4·35	5·0N *d*	21·3 *a*	16·3 *b*	2, 29, 6
4	13·1	11·0N *b*	19·20 *a*	8·20 *c*	4, 20, 23
5	*c* 7·3	19·0N *c*	12·32	6·28 *d*	5, 21, 22, 27
6	(*a*) 2·9	13·5N *b*	3·10 *c*	16·10 (9·55) *b*	6, 2, 29
7	(*b′*) 16·34	19·0S *c*	3·7 *c*	22.7 (15·53) *b*	7, 25
10	*d* 23·31	14·11N *b*	16·20 *b*	2·9 *e*	10, 11, 13′
11	*d* 23·31	13·0N *b*	16·20 *b*	3·20 *e*	11, 10
12	(*a*) 2·35	19·0 *c*	17·26 *b*	1·34 *e*	12, 6, 2, 29
13	(*b′*) 17·1	14·13N′ *b*	18·13 *b*	4·0 *e*	13, 10, 11
15	*a* 9·21	9·0S *a*	19·24 *a*	10·24 *c*	15, 1, 28
17	*d* 12·24	18·0S *c*	20·15 *a*	2·15 *e*	17, 27
18	(*b*) 17·7	10·0S *a*	21·21 *a*	11·21 *a*	18, 19
19	(*b*) 17·7	10·0S *a*	21·21 *a*	11·21 *a*	19, 18
20	*e* 22·11	15·0N *b*	22·13 *a*	7·13 *d*	20, 4, 23
21	*e* 22·11	15·0N *b*	22·13 *a*	7·13 *d*	21, 22, 27, 5
22	*d* 23·12	17·0N *c*	22·21 *a*	5·21 *d*	22, 21, 27, 5
23	(*a*) 2·19	14·59N *b*	22·52 *a*	7·53 *c*	23, 4, 20
25	*c* 7·20	8·0′S *a*	23·14 *a*	15·14 (31·14) *b*	25, 7
27	*d* 24·0	18·0S *c*	22·51 *a*	4·57 *e*	27, 17
28	(*a′*) 14·25	9·20N *a*	22·33 *a*	13·13 *a*	28, 1
29	(*a′*) 15·17	5·0N *d*	22·27 *a*	17·27 *b*	29, 2, 6

(1) Latitudes of Earthquakes alike:
- 1, 2, 4, 5, 6, 7, 10, 11, 12, 13, 15, 17, 18, 19, 20, 21, 22, 25 [and 27
- 3, 16 and 29
- 8, 9, 14, 24
- 23, 28.

(2) Transits alike:
- 1, 6, 12, 23, 28, 29
- 2, 3, 7, 13, 14, 18, 19, 24
- 4, 17, 27
- 5, 9, 25
- 8, 9, 15, 20, 21, 26
- 10, 11, 16, 22, 27.

(3) Moon's Declinations alike:
- 1, 3, 15, 18, 19, 25, 28
- 2, and 29
- 4, 6, 10, 11, 13, 14, 15, 18, 19
- 5, 7, 12, 17, 22, 26, 27
- 8, 9, 24, 29
- 16, 20, 21, 23.

(4) Latitudes and Transits alike:
- 1, 6
- 2, 7, 13
- 5, 25
- 8, 9
- 22, 27.

(5) Latitudes and Declinations alike:
- 4, 10, 11, 13, 15, 18, 19
- 5, 12, 17, 22
- 8, 9, 24.

(6) Transits and Declinations alike:
- 3, 18, 19
- 10, 11, 13, 14, 18, 19
- 17, 27
- 8, 9
- 20, 21.

No.	Date.		Lat.	Long.	Transit.	Parallax.	Moon Dec.	Sun Dec.	Differences.	
21	June 3.	Baku	41°N	48°E	22·11	60·51	15°0'N	22°13'	7·13	37·13
22	,, 4.	Chaco	42°S	73°W	23·12	61·16	17·0	22°21'	5·21	39·21
27	July 5.	Salonica	41°N	23°E	24·0	60·59	18·0N	22°51'	4·51	40·51
5	Feb. 16.	Schemacha	41°N	48°E	7·3	59·15	19°N	12·32	6·28	31·32

In these cases there is a similarity in the latitudes and in the transits of Nos. 21, 22, and 27, and, in all, the moon was near its time of perigee. There is also much agreement in the declinations of the moon and sun and their differences.

No.	Date.		Lat.	Long.	Transit.	Parallax.	Moon Dec.	Sun Dec.	Differences.	
4	Jan. 24.	Lisbon	39°N	9°W	13·1	58·35	11°0'N	19°20'S	8·20	30·20
20	June 3.	Villetri Italy	42°N	13°E	22·11	60·51	14°5'N	22°13'N	8·8	36·18
23	,, 9.	Cheshire	53°N	2°W	14·49	60·5	14°57'N	22°52'N	7·55	37·49

In these cases as latitude increases there is a corresponding widening in the times of transit. The moon is near its perigee and the differences between the lunar and solar declinations are very much alike.

No.	Date.		Lat.	Long.	Transit.	Parallax.	Moon Dec.	Sun Dec.	Differences.	
18	May 28.	Cape Peninsula	35°S	18°E	17·7	55·46	10°0'S	21°21'N	11·21	31·21
19	,, 28.	Greece	38°N	23°E	17·7	55·46	10°0'S	21°21'N	11·21	31·21

The zenith and nadir tides are almost coincident.

No.	Date.		Lat.	Long.	Transit.	Parallax.	Moon Dec.	Sun Dec.	Difference.	
17	May 22.	Creusot	46°N	4°E	12·24	53·59	18°0'S	20°15'N	2·15	38·15
27	July 5.	Salonica	41°N	23°E	24·0	60·59	18°55'N	22°51'N	3·56	41·46

An interval of 44 days—a lunation and a half—transits at noon and about midnight respectively.

Parallax—apogee and perigee respectively.

Declinations of the moon—about equal distance north and south of the equator respectively.

Differences in declination similarly reversed.

No.	Date.		Lat.	Long.	Transit.	Parallax.	Moon Dec.	Sun Dec.	Differences.	
10	May 5–6.	Murcia	38°N	1°W	23·31	60·53	14°11′N	16°20′N	2·9	30·31
11	„ 6.	Bordeaux	45°N	½°W	23·51	60·53	14°11N	16·20N	2·9	30·31
13	„ 12.	Croatia	46°N.	16°E	17·1	57·57	14°13′N	18°13′N	4·0	32·26

Nos. 10 and 11 are practically alike. The exact times of the shocks are not given, but the factors would be nearly similar to those stated. The earthquake in Croatia bears a great similarity to that of the other two, especially Bordeaux.

No.	Date.		Lat.	Long.	Transit.	Parallax.	Moon Dec.	Sun Dec.	Differences.	
7	Mar. 29.	Lucca	44°	10°E	16·34	54·22	19°0′S	3°7′N	15·53	22·7
25	June 14.	Sicily	37½°N	15°E	7·20	55·21	8°0′S	23°14′N	15·14	31·14

The moon's transit in the case of No. 7 is about as much after midnight as No. 25 is before. There is not much difference in parallax, and the differences between the lunar and solar declinations 15°53′ and 15°14′ are practically the same.

No.	Date.		Lat.	Long.	Transit.	Parallax.	Moon Dec.	Sun Dec.	Differences.	
1	Jan. 12.	Nova Scotia	45°N	65°W	2·11	59·31	8°50′S	21·45S	12·55	30·35
28	July 5.	Cheadle, Cheshire	53½°N	2¼°W	14·25	58·30	9°20′N	22·33	13·13	31·53
15	May 18.	San Francisco	37°N	123°W	9·21	54·57	8°33′S	19·24	10·51	27·57

In these cases No. 28 is about as much above No. 1 in latitude as No. 15 is below. The time of transit of No. 1 is about as much after noon as No. 28 is after midnight and No. 15 before midnight; there is a considerable similarity in the moon's and sun's declinations and their differences.

No.	Date.		Lat.	Long.	Transit.	Parallax.	Moon Dec.	Sun Dec.	Differences.	
2	Jan. 15, 16.	Croatia	46°N	16°E	4·35	58·6	5°0′N	21°3′S	16·3	26·3
29	July 9.	Bandar Abbas	27°N	56°E	15·17	57·57	5°0′N	22°37′N	17·37	27·37
6	Mar. 13.	Ichangerian Turkey	41°N	28°E	14·36	59·37	13°5′N	3°10′S	9·55	16·15

There is a similiarity in the transits in these cases with respect to noon and midnight. Nos. 2 and 29 are very much alike with regard to lunar and solar declinations and their differences; and the sum of the declinations in No. 6 is about the same as the difference of the deductions in No. 2.

THE GREAT LISBON EARTHQUAKE, 1755

EXPLANATION OF DIAGRAM.

In this diagram the whole of the earth's surface from 60° N. lat. to 60° S. lat. is represented. In the middle of the diagram is the meridian of Lisbon, and at twelve hours, or 180° to the extreme right and left, is the anti-meridian of Lisbon. Round a fitting cylinder the anti-meridians would exactly meet so that an approximate representation of the Earth's rotundity might be obtained. The diagram, allowing for rotundity, has been drawn approximately to scale.

On October 31 at 21h. astronomical time, or 9h. a.m. on November 1, when the earthquake occurred, the sun was at S^{21}, nearly 15° S. lat., with the moon to the N. W, in lat. nearly 4° S., so that a line drawn from the position of the sun on the earth's surface through the position of the moon goes straight to Lisbon, as indicated in the diagram, and not only so, but the maximum tide-lifting curves at an angle of 45° from the positions of the moon M^{21} and the sun S^{21} cut at A, 39° S. lat., and that at the same angle from the nadir positions of the moon M'_{12} and the sun S'_{12} these great tide-lifting curves cut at 39° N. lat. Therefore, at the time of the earthquake, the zenith and nadir tides were both culminated upon Lisbon and its environment. In an ordinary earthquake only one of these tides acts upon the centre of disturbance, but, in this rare instance, through the culmination of two of the most powerful zenith and nadir tides, the power of the moon and sun were for the nonce really doubled. The result was that the earth actually reeled and staggered in its course, acted upon by the doubled powers of these great luminaries in the neighbourhood of Lisbon. If we put the moon and sun in position from midnight M^{21} and S^{21} respectively up to M^{21} and S^{21} we find that the declination of the moon increases by about 1°30′, while that of the sun only increases about 10′; the effect of this continuous increase is—(taken with the gradual approach of these luminaries by about 4°, or 15 minutes in time)—that the tide-lifting

curves from the sun and moon cut about 42° S. lat., at J, the latitude decreasing gradually through I, H, G, etc., until A is reached, when the latitude is 39°. In the same way the nadir points of section of the 45° curves proceed from J′ through I′, H′, etc., until A′ is reached at the latitude of 39°, the latitude of Lisbon.

In fact the nadir line of section of the tide-lifting curves from J to A correspond with that from J′ to A′.

Further, due to the fact that A and A′ did not quite reach to the meridian and anti-meridian, the centre of the profound disturbance was momentarily thrown to C, in the ocean, but during the time occupied by the gigantic movement A and A′ rapidly approached the meridian and anti-meridian, and the overwhelming tidal and up-and-down heaving force was thrown forward in the direction of, and eventually to, Lisbon, the crust oscillation or vibration taking much less time than that of the water, the consequence being the withdrawal of the ocean, and its return with overwhelming and appalling force. By these heavings of the bed of the ocean enormous waves were formed on all sides, and vessels in the Atlantic were affected as if they had suddenly struck on a rock or a sand-bank. A ship, 120 miles west of Cape St. Vincent, experienced such a violent shock that the men were thrown upwards for nearly two feet; in other cases every person and everything on board was overthrown, although there was deep water all round. The sea rose to a height of sixty feet at Cadiz, and destroyed the mole and fortifications. Lisbon, being nearest, suffered most, but Setubal, a village twenty miles south, and another in Morocco, were engulfed. The hot springs in Toplitz, Bohemia, were dried up for a time, and afterwards burst forth again suffused with ochre. Loch Lomond, too, felt the shock.

Thus, after the lapse of 147 years, a full and satisfactory explanation has been given of the greatest earthquake of historical times. This earthquake was unique from the fact that both the zenith and nadir tides, at their maximum, combined at the latitude of Lisbon, and that the line joining the position of the sun and moon indicated Lisbon and its vicinity as the seat of the disaster. The magnitude of the disaster will be appreciated when it is observed that it actively affected the area within the dotted line, about four times the area of the whole of Europe.

THE KASHGAR EARTHQUAKE OF AUGUST, AND THE SICILIAN CYCLONE OF SEPTEMBER, 1902, COMPARED

	Transit.	Parallax.	M. Dec.	S. Dec.
Kashgar 21/8/02	14·48	57′30″	3°54′N	12°25′N
Catania 25/9/02	19·48	58·59	16°56′N	0°54′S
Differences	5·0	1·29	13·2	13·19
Cross Differences	—	—	4·31	4·48
Values	10	0·4	37	—

In the accompanying figure (Fig. 22), O O represents the meridian of Kashgar or Catania, E E the equator, SK and SC denote the relative position of the sun at the time of the earthquake and the cyclone respectively. and MK and MC the relative positions of the moon at the time. The parallelism of the positions of the moon and sun may be observed, the line joining the position of the sun at the time of the earthquake with the position of the moon at the time of the cyclone being parallel to the line joining the position of the sun at the cyclonic period with the position of the moon at the time of the earthquake.

It will be observed from the figures given above that the difference between the declinations of the moon, 13°2′, is very approximately equal to 13°19′, the difference between the declinations of the sun and the cross differences are also practically equal. The mean difference is about 4°40′ ·37 bar., to which, if ·04 be added, and ·10 deducted, we have ·31, the approximate difference in the heights of the barometer at London on those days.

THE SICILIAN CYCLONE.

In Fig. 23, when the moon M was on the anti-meridian of Catania, in Sicily, where the great cyclone oc-

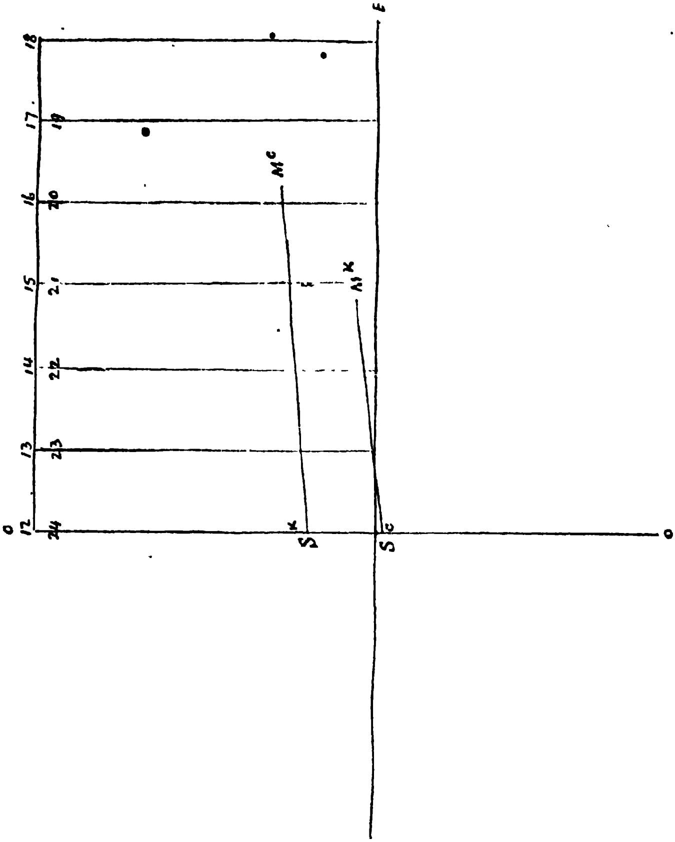


Fig. 22.
THE KASHGAR EARTHQUAKE, September 1902.

curred on September 25–26, 1902, the sun was at S, and at the time when the cyclone was at its height was near midnight on the 25th, at S′, the moon being at M′.

In Fig. 24 C is the position of Catania on the meridian O O 37½° north of the equator E E. The figures at the top to the right and left of the meridian of Catania O O denote the hours before and after midnight. At the time of the cyclone the sun was in the position S′ 0°45′ south of the equator, while the moon was 17°2′ north of the equator; but as the cyclone was produced by the nadir effects of both luminaries, the nadir tide of the sun would be thrown 45′ north at S, while the corresponding lunar tide would be thrown 17°2′ south at M, the angular distance of the moon from Catania being 90°, while that of the sun approached 45°. Thus the sum of the angular distances would approach 140°, the sum of the angular distances of the moon and sun at the time.

THE KASHGAR EARTHQUAKE

In Fig. 25, M denotes the position of the moon on the meridian of Kashgar when the sun was at S, about three o'clock in the morning. About five hours afterwards the earthquake occurred, when the moon was at S′. During the time the sun moved from S to S′ the moon moved from M to M′. At the time of the earthquake, therefore, the sun was at S′ and the moon was at M′. The angular distance between Kashgar on the morning of August 22, 1902 (when the earthquake occurred there) and the sun (see S, Fig. 26), then over 12° north of the equator, was 60°, and the angular distance between that place and the moon (see M, Fig. 26), nearly 4° north of the equator, was about 80°, the sum of the angular distances, 140°, agreeing very closely with the sum of the angular distances for earthquakes generally.

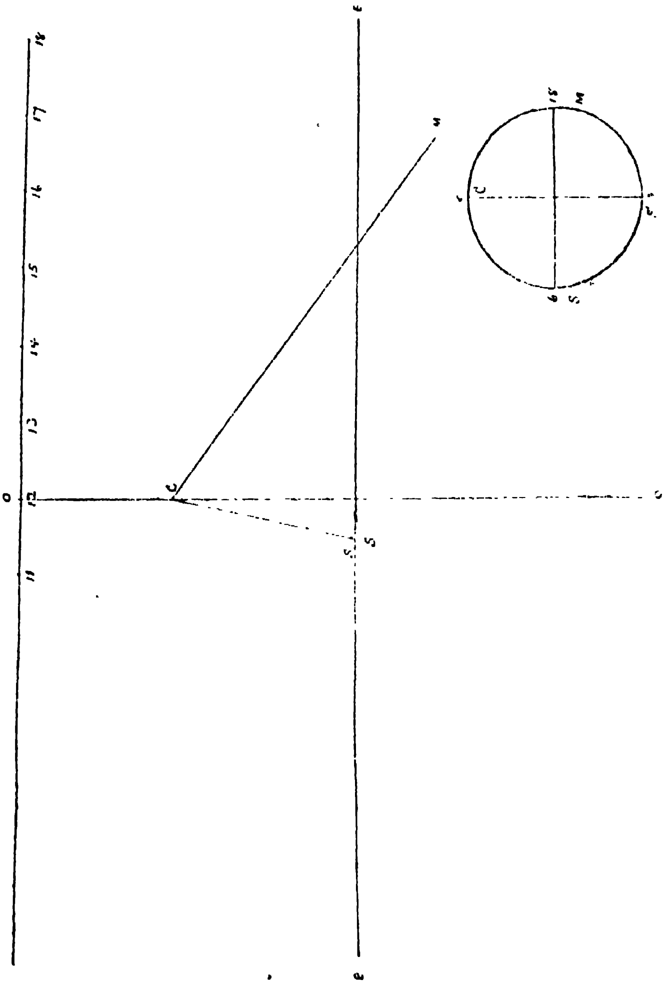


FIG. 23.

FIG. 24.

THE CYCLONE IN SICILY, SEPTEMBER 1902.

In Fig. 26 O O represents the meridian of Kashgar, E E the équator, K the position of Kashgar on the meridian, and S and M the relative positions of the sun and moon at the time of the earthquake. The figures at the top to the right and left of the meridian are the hours of the day, from twenty hours astronomical time (8 a.m.) to 5 p.m., the sun S being four hours east of the meridian, while the moon M was five hours west at the time of the earthquake.

At 1.30 on the morning of August 22, the moon was exercising its greatest 'pull' over Kashgar at an angle of 45°; at 3 o'clock, when the moon was on the meridian of the town at an angle of 36°, the lunar pull was less, but the solar pull increased until 2.20 a.m., when it was acting at an angle of 45°, so that the combined pull when the moon was on the meridian would not be diminished, and would keep on increasing to 4.30 a.m., when the moon would again be at an angle of 45°, exercising its greatest pull; this maximum effect of the moon, together with the pull of the sun, would go on increasing for three and a half hours longer, so that at 8 o'clock on the morning of August 22, the combined forces of the moon and sun at angles of 80° and 60° respectively from Kashgar became irresistible, and the earthquake which then occurred was inevitable.

Great storms are caused in our atmosphere by the moon and the sun. They are the natural consequence of the attractive influence of those bodies, but the consequence, primarily, of the motions of the moon. Less or greater pulsations in the fluid matter of the earth's interior and in the outer crust of the earth's surface are caused and are propagated in the form of great waves of translation, often causing enormous ruptures in strata above or below the surface of the earth which in their turn may give vent to lava, heated rocks, and dust, with mephitic vapours. The correct theory of earth-

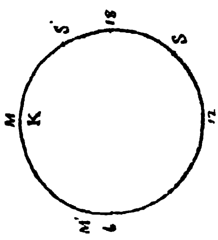


Fig. 25.

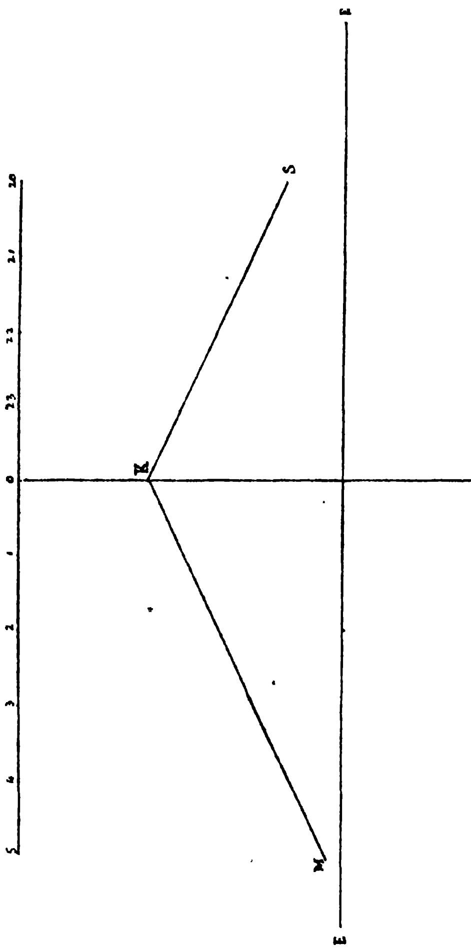


Fig. 26.

quakes would seem, in view of the evidence here recorded, to be that the crust of the earth and the fluid and elastic matters beneath the crust are acted upon similarly to the atmosphere and the ocean, and, simultaneously with the air and water, by the combined forces of the moon and sun. All the phenomena connected with and incident to the causation of earthquakes can be accounted for on the basis of the moon's motions and, apparently, in no other way.

The discoveries of Mr. Clements in this region of natural phenomena are especially applicable to the circumstances reported concerning Martinique and the earthquakes which accompanied and were followed by the eruptions of Mont Pelée. Professor J. Milne is reported to have stated [1] with regard to the first eruption at St. Pierre, that 'it was due to the infiltration of water through the rocks in some way until it reached the molten material beneath the earth's crust. Aqueous vapour is formed which, under the tremendous expansive power wrought by heat, exercises such prodigious pressure that something has to give way, and an explosion follows.' The Professor does not explain why this infiltration of water through the rocks to the lava streams were so long as fifty years in reaching the explosive element. A little consideration will, probably, make it clear to him, as it does to Mr. Clements and the present writer, that the water does not, in sufficient quantity for large explosive effects, percolate to the lava by the slow process of infiltration, but is suddenly sucked in to supply the vacuum caused by the undulatory movements of the lava, breaking its continuity into rents and fissures into which water in large quantities penetrates and almost instantaneously is converted into steam by the hot lava and then ejected with great violence by the enormous pressure that has been suddenly generated.

[1] *Nature*, June 1902.

APPENDICES

I. Graphic Delineations of Lunar and Solar Positions for the Earthquakes named on Figures

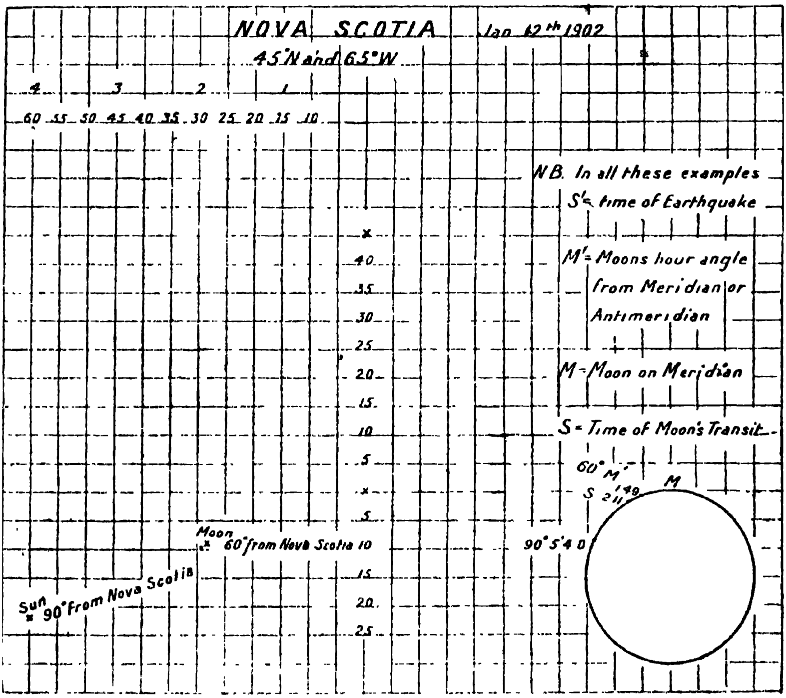


FIG. 27.

N.B. The central vertical line in each diagram represents the meridian of the place where the earthquake occurred along which the latitudes are given, a cross denoting the latitude of the place.

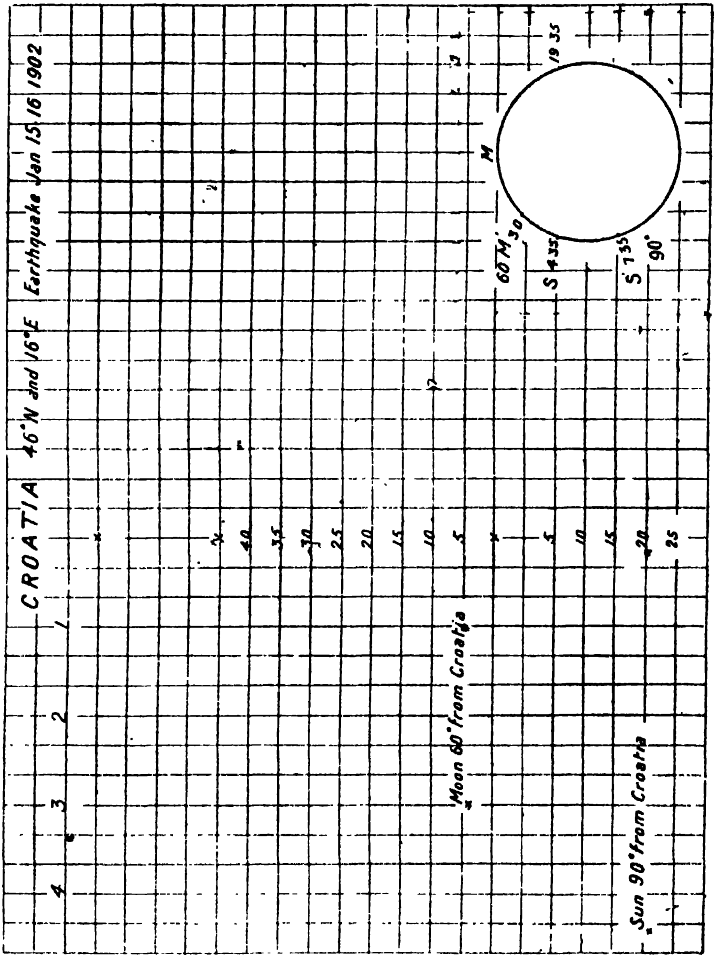

CROATIA 46°N and 16°E Earthquake Jan 15.16 1902
Moon 60° from Croatia
Sun 90° from Croatia
M
60 M 30
S 4 35
S 7 35
19 35
90°
40
35
30
25
20
15
10
5
5
10
15
20
25
1
2
3
4

FIG. 28.

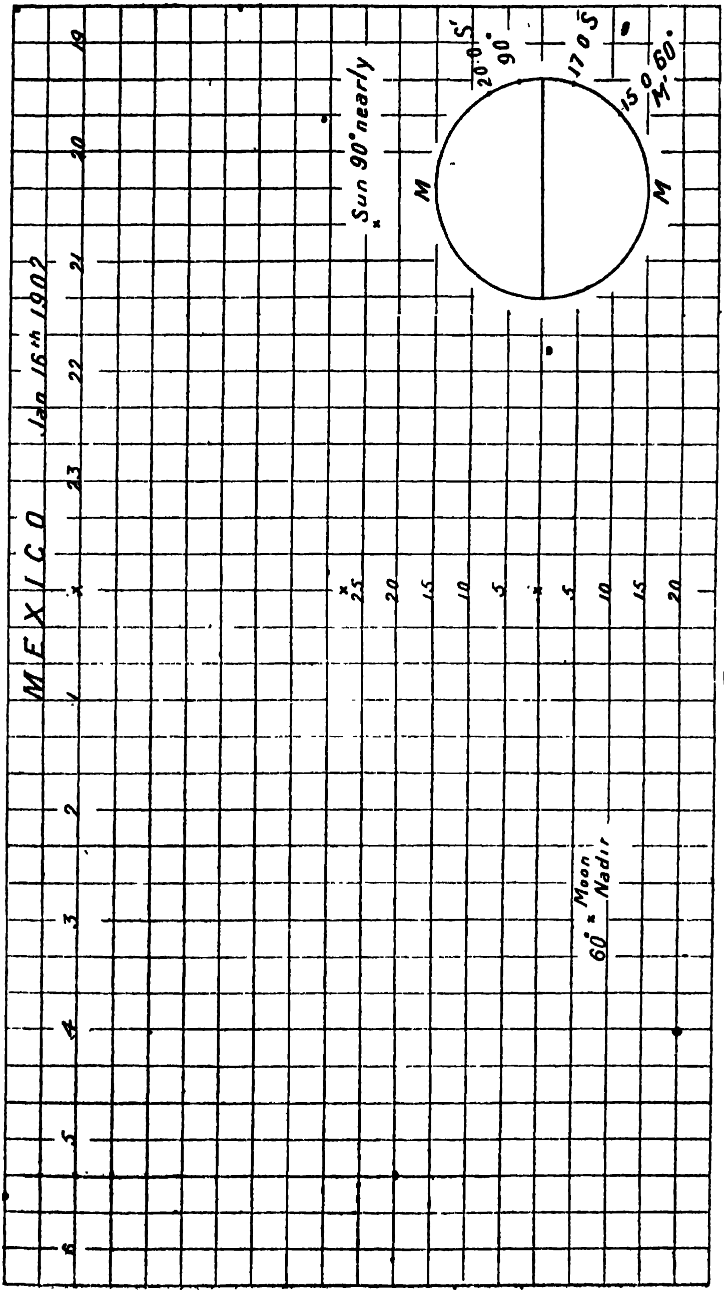

MEXICO Jan 16th 1902
Sun 90° nearly
M
M
20·0 S' 90°
17 0 S
15 0 M 60°
60° Moon Nadir
19 20 21 22 23 x 1 2 3 4 5 6
25 20 15 10 5 x 5 10 15 20

FIG. 29.

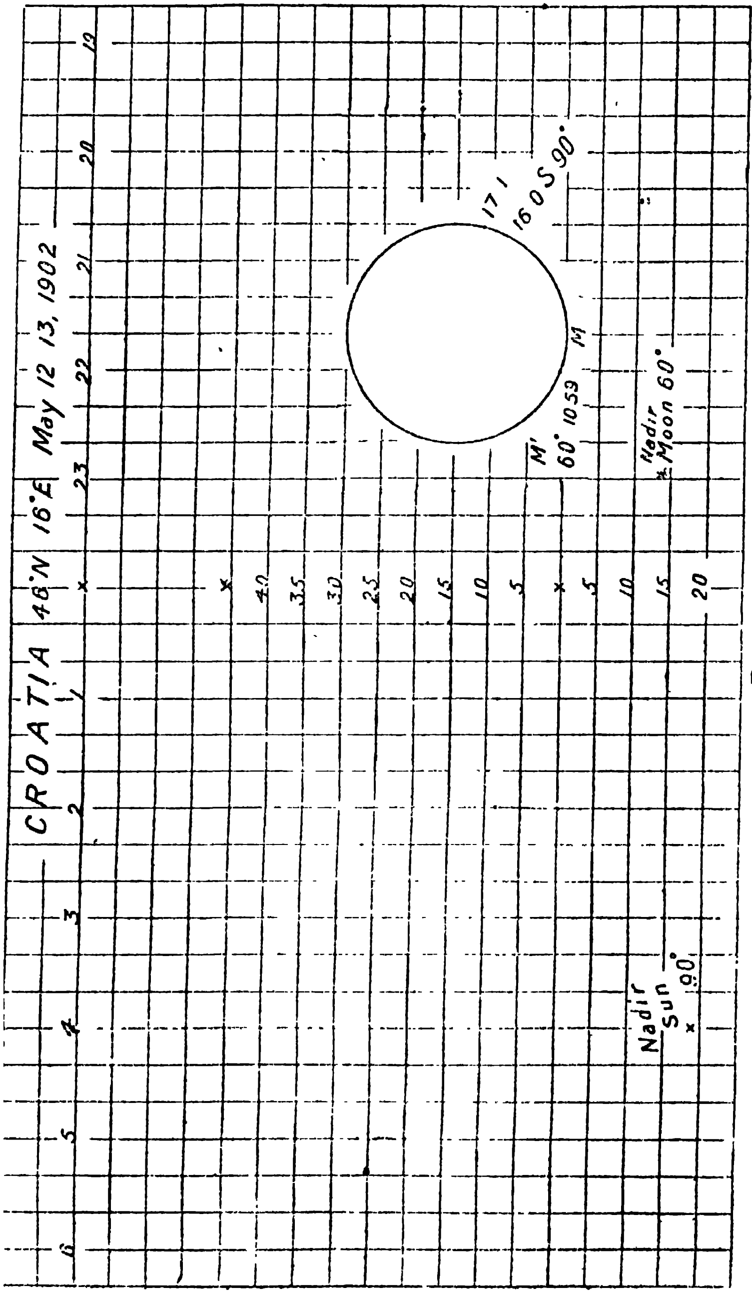
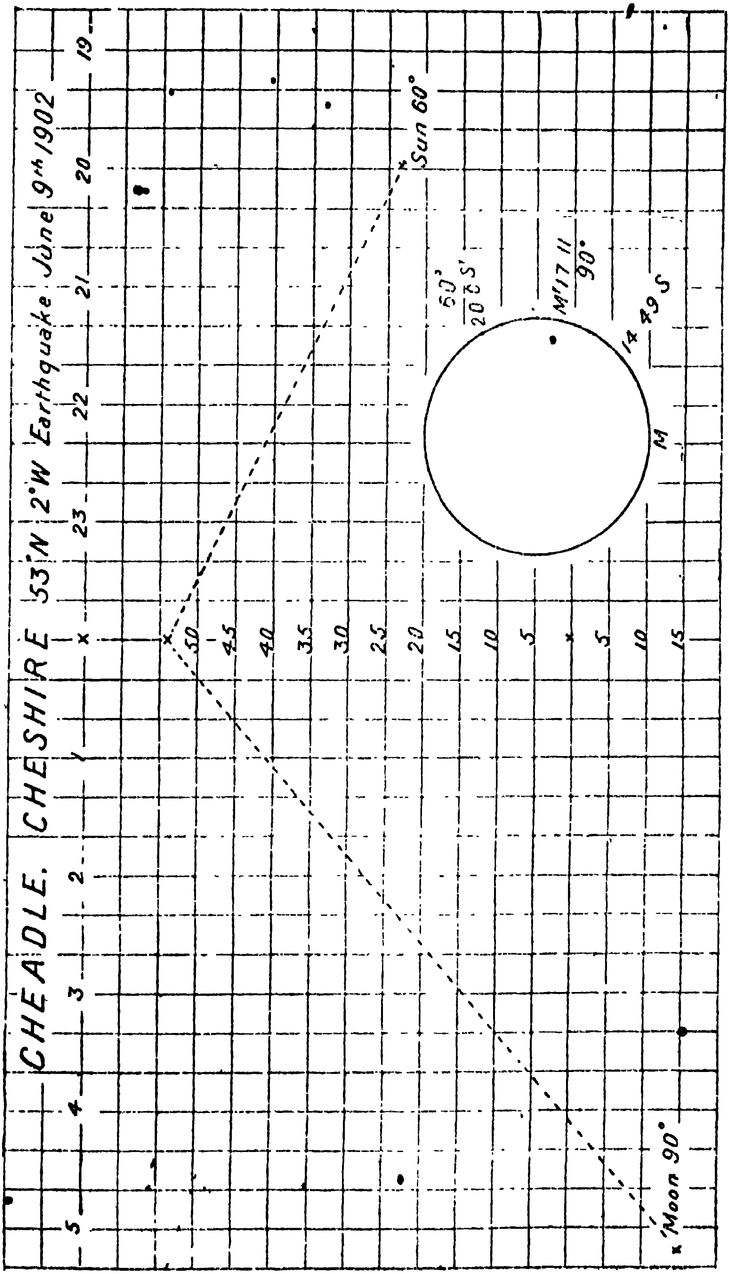

CROATIA 46°N 16°E May 12 13, 1902
Nadir Moon 60°
Nadir Sun 90°
M
M'
60° 10.59
16 0 S 90°

FIG. 30.


CHEADLE. CHESHIRE 53°N 2°W Earthquake June 9th 1902
Sun 60°
Moon 90°
M 17 11
90°
14 49 S
M

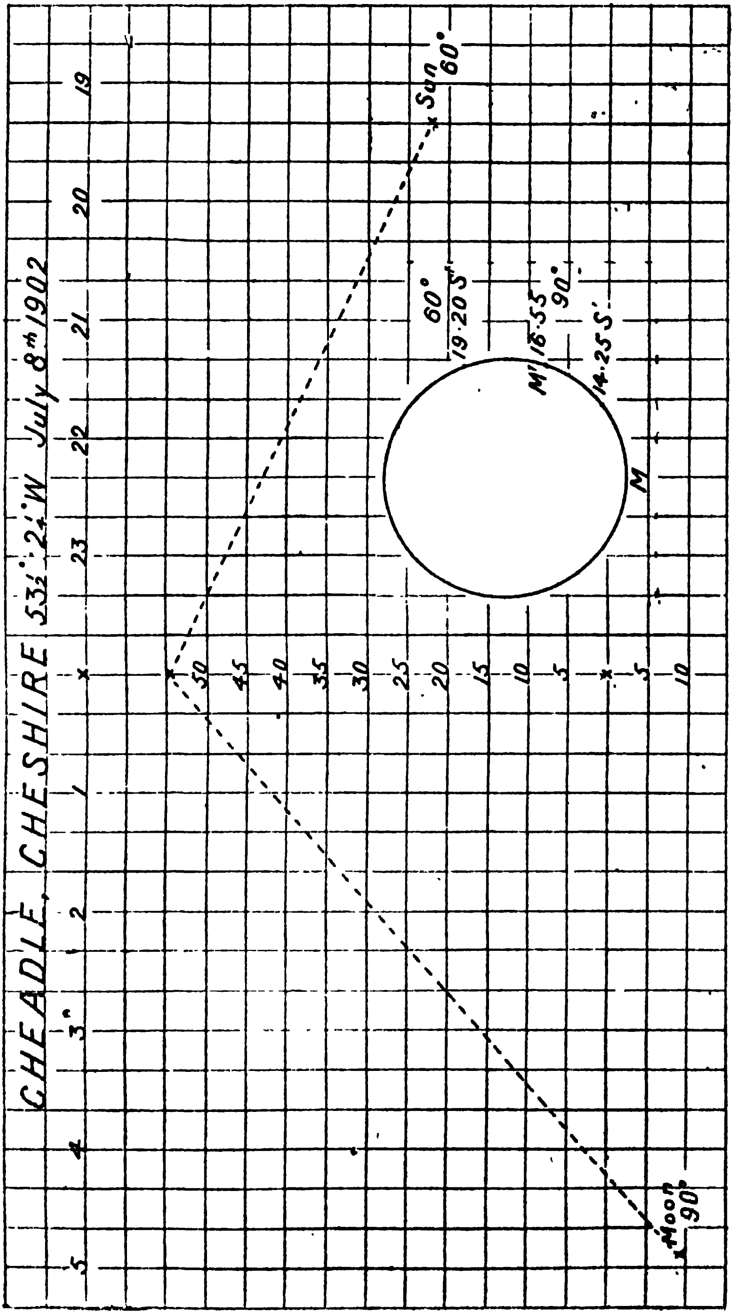

CHEADLE, CHESHIRE 53½° 2¼° W July 8th 1902
Sun 60°
Moon 90°
60° 19·20 S
M' 18·55 90°
14·25 S
M
19 20 21 22 23 1 2 3° 4 5
50 45 40 35 30 25 20 15 10 5 5 10

FIG.

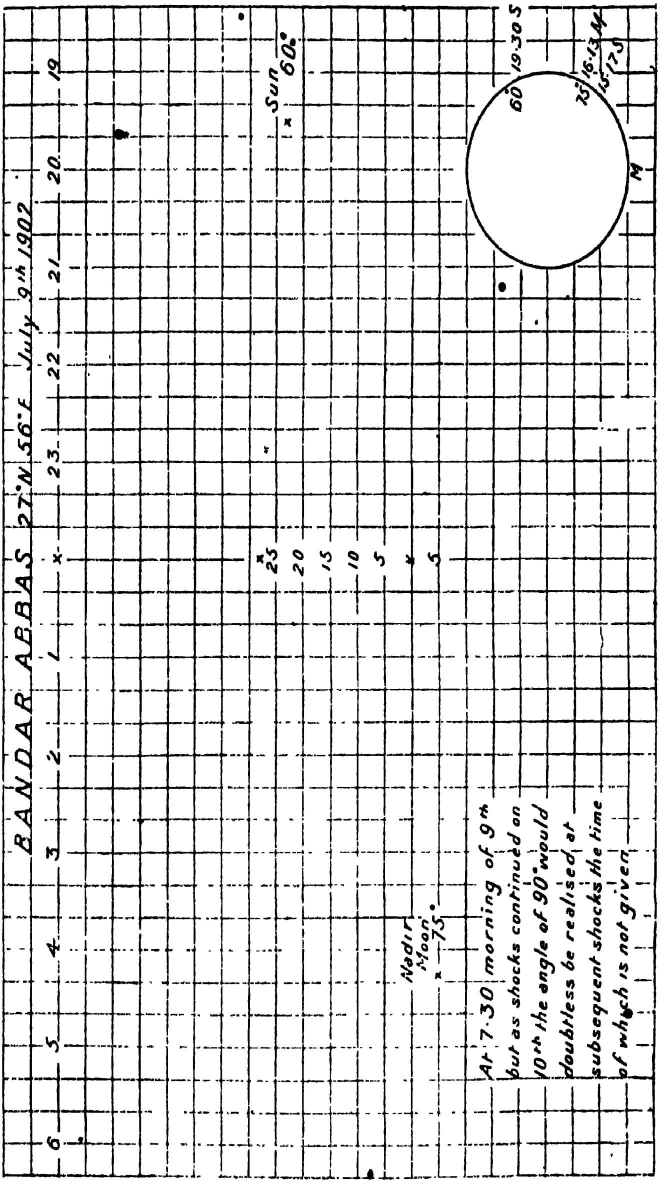

BANDAR ABBAS 27°N 56°E July 9th 1902
19
20
21
22
23
1
2
3
4
5
6
Sun 60°
25
20
15
10
5
5
Nadir Moon 75°
60
19·30 S
75
16·13 M
15·17 S
M
At 7·30 morning of 9th
but as shocks continued on
10th the angle of 90° would
doubtless be realised at
subsequent shocks the time
of which is not given

FIG. 33.

II. The Moon's Tangential Pull.

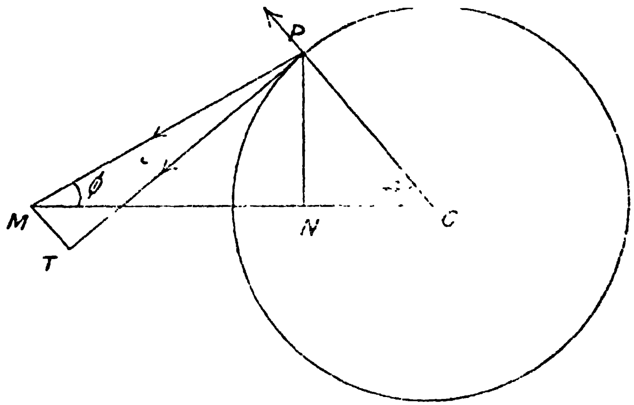


FIG. 34.

To find what line represents the moon's total pull, assuming that PT represents the tangential pull.

MT represents the normal pull.

$$
\begin{aligned}
MT &= PM \sin M\hat{P}T \\
&= PM \cos(\theta + \phi) \text{ from } (2) \\
&= \frac{r \sin\theta \cos(\theta + \phi)}{\sin\phi} \\
&= r \sin\theta \left\{ \frac{\cos\theta \cos\phi - \sin\theta \sin\phi}{\sin\phi} \right\} \\
&= r \sin\theta \left\{ \frac{2\cos\theta}{\tan\theta} - \sin\theta \right\} \text{ from } (1) \\
&= 2r\cos^2\theta - r\sin^2\theta \\
&= 2r\cos^2\theta - r(1 - \cos^2\theta) \\
&= 3r\cos^2\theta - r
\end{aligned}
$$

When $\theta = 0$, the normal force represents the moon's total pulling force at a point directly underneath it. This force is therefore $3r - r$ or $2r$.

Call this P. Hence the tangential force $= \frac{3r}{2} \sin 2\theta$.

$$= \frac{3P}{2} \sin 2\theta$$

$$MN = 2\,NC \quad \therefore \quad \tan\theta \left(\frac{PN}{NC}\right) = 2 \tan\phi \left(\frac{PN}{MN}\right) \quad (1)$$

$$M\hat{P}C = \pi - (\theta + \phi) \quad \therefore \quad M\hat{P}T = M\hat{P}C - T\hat{P}C$$

$$- (\theta + \phi) \quad (2)$$

$$PM = \frac{PN}{\sin\phi} = \frac{PC \sin\theta}{\sin} = \frac{r \sin\theta}{\sin\phi}$$

$$PT = PM \cos M\hat{P}T = \frac{r \sin\theta}{\sin\phi} \sin(\theta + \phi) \text{ from } (2)$$

$$= \frac{r \sin\theta}{\sin\phi} (\sin\theta \cos\phi + \cos\theta \sin\phi)$$

$$= r \sin\theta \left(\frac{\sin\theta}{\tan\phi} + \cos\theta\right)$$

$$= r \sin\theta \left(\frac{2 \sin\theta}{\tan\theta} + \cos\theta\right) \text{ from } (1)$$

$$r \sin\theta .\ 3 \cos\theta$$

$$\frac{3}{2} r (2 \sin\theta \cos\theta)$$

$$= \frac{3}{2} r \sin 2\theta. \quad \therefore \quad \text{As } r \text{ is}$$

a constant, PT, and consequently the tangential pull of the moon, varies as the sine of twice the altitude θ.

CHAPTER IV

Wind-Storms and their Origin

Meteorologists most At Sea in regard to Wind Causation.
The *Encyclopædia Britannica's* Strange *Obiter Dictum* on the Cause of Weather Changes.
'The Engine-Room' whence Motive-power for Wind-production is obtained—*W. Allingham.*
'The Sun is the Real Disturber of the Weather'—*W. H. M. Christie*, Astronomer Royal.
Unfitness of Solar Heat Theory to Account for Winds—*Hon. Ralph Abercromby.*
'Each Element of Climate is Liable to a Regular Daily Change'—*A. Ramsay.*
Mr. W. C Redfield, the Pioneer of Storm-Movements Verifications.
Mr Clements Surprising Successes in Wind-Prediction
'More Storms Occur when the Moon Transits the Anti-Meridian at Midnight or thereabouts'—*Hugh Clements.*
Detailed Statement as to Time when Gales Most Frequently Occur.

(*a*) Gales when the Moon Crossed the Meridian about Noon and near Midnight.
(*b*) Gales that Happened near the Time of the Moon's Quarters
(*c*) Gales when the Moon Crossed the Meridian about 9 a.m or 9 p m.
(*d*) Gales when the Moon Crossed the Meridian about 3 a m. or 3 p m

The Various Forces Producing a Calamity such as that at Galveston, Texas, September 8, 1900.
Internal Forces in the Earth and External Action.
Neither the Stars nor the Planets, and not even the Sun, but the Moon, the Controlling Force.
Scientific Demonstration (with Three Diagrams) of the Manner and Effect of the Force Exerted.
Graphic Description of the Catastrophe.
Physical Configuration of the Region Accountable for the Damage Done.
Fourth Diagram and Final Demonstration.

HOW greatly meteorologists are content to busy themselves with visible phenomena as the main, if not the sole, object of their investigations, instead of getting at the back of the phenomena themselves, whether the media be visible or invisible, is nowhere so much apparent as in relation to the causation of winds and wind-storms. It is admitted that the more regular seasonal changes in the Far East may make prediction possible for that part of the world. But, when Europe is approached, then the difficulty becomes insurmountable. Especially is this alleged to be the case so far as the United Kingdom is concerned. And, on the methods adopted, the difficulty is insurmountable. The forecasting of storms for the British Islands is declared to be 'complex and difficult, particularly for the western districts of these islands.' In a phrase which, in the light of the real causes of weather changes, becomes monumental in its unfitness to explain the phenomena, it is said:

'The great difficulty lies in the fact that the British Islands are immediately bounded by the Atlantic to

westwards; and since practically every storm and nearly all weather-changes come from that direction, no telegraphic communication of their approach can be received.'[1]

The phraseology of the assumed fact is unfortunate. It conjures up in the mind a huge storm-factory in the centre, or at some eccentric part, of the Atlantic, wherein storms are manufactured and despatched to the British Isles by a universal provider in weather commodities. To such a conception does the mathematical and physical *reductio ad absurdum* apply. Nevertheless, the simile seems a favourite one with writers on meteorology. Mr. William Allingham declares that 'tropical regions are, as it were, the engine-room where the motive power for the world's wind-circulation is produced and maintained.'[2] Such an image is not altogether inexact so long as Mr. Allingham and meteorologists generally believe that 'equatorial heat and polar cold, together with the earth's rotation and the relative distribution of land and sea, practically determine the wind-circulation of our planet.'[3] Each and all of these things do, no doubt, play some part—some small part only—in the

[1] *Encyc. Brit.*, Ninth Edition, art. 'Meteorology,' p. 158. It seems to be overlooked that there are many other portions of the world situated, in relation to sea and ocean, as the British Isles are situated in respect to the Atlantic Ocean.

[2] *A Manual of Marine Meteorology*, by William Allingham, p. 50. Charles Griffin and Co., 1900.

[3] *Ibid.* This statement is expanded in the following sentences, which are to be found on the quoted page of Mr. Allingham's book: 'One portion of the earth is warmed by the sun more than the adjacent portions, thus causing the relatively warm air to expand and rise over the warmer area. Hence ensues a change both in the barometric pressure and in the specific gravity of the air, as also a surface wind which flows towards the warmed area on the principle that "Nature abhors a vacuum." Tropical regions are, as it were, the engine-room where the motive power for the world's wind-circulation is produced and maintained. The rotation of the earth on its axis deflects the moving air from the shortest distance between any two points on the earth's

manifestation of wind-movements, but they are not the origin of those movements. Mr. Christie, the Astronomer Royal, writing from the Royal Observatory at Greenwich in November 1893, put a like truth in more uncompromising and as little truly scientific language. 'The sun,' he said, 'is the real disturber of the weather; his action on the atmosphere, combined with the revolution of the earth on its axis, producing all the changes we experience. It is the influence of solar heat.' As fully explanatory of weather phenomena the theory will not work. As a strictly subordinate agency solar heat has a share in the causation of wind-circulation.

The Hon. Ralph Abercromby, himself most orthodox in many of his views on modern meteorology, shows the unfitness of the solar heat theory to explain everything that happens. 'Theoretically,' he says, 'any small difference of temperature should set up a wind from the cold to the hot area; but we have seen already and shall still see more in our next chapter on Heat and Cold that differences of temperature, even over large areas, have wonderfully little influence on wind. The most that local differences of heat and cold do is to set up local breezes, such as land and sea, or valley, winds. Then, theoretically, this cold wind should blow nearly straight towards the hot area, only a little deflected to the right or left, according to circumstances, by the earth's rotation. In like manner, any difference of

surface; towards the right in the northern, and towards the left in the southern hemisphere.

'Since winds are due, in the first instance, to inequalities in temperature, they may conveniently be divided into three broad classes depending upon the fixity of the predisposing causes, and are either constant, periodic, or variable.

'Constant winds blow towards the tropical regions of continuously high temperature. Periodic winds are due to unequal heating of land and sea, whether the period is annual or diurnal. Changeable winds prevail where the heating of land and sea is capricious.'

pressure, from the high to the low barometer, however caused, should draw wind nearly straight. But, in our chapter on Diurnal Weather we shall find some land and sea breezes which blow nearly parallel to the coast line.'[1]

Again: 'We may conceive that in the general circulation of the hot air of the equator towards the Pole, the direction of the currents will be profoundly modified by the surface temperature of the earth, and that it is perhaps easier to flow over a cold surface at one season and a warm one at another. However that may be, we are met by the apparent contradiction that, though the daily variations of temperature are undoubtedly the product of the motion of cyclones, etc., the broad situations of the areas of cyclonic activity are themselves due to radiation. The truth probably is that both inferences are correct in a modified degree. . . .'[2]

Another instance of a phenomenon absolutely unexplainable by the solar heat theory is afforded by diurnal periodicity. Diurnal periodicity is simply a manifestation of the atmospheric tides. In the torrid zone it usually gives two maxima of barometric pressure, and two minima, every twenty-four hours. Like oceanic tides it is absent at the Poles. The following, taken from Mr. A. Ramsay's *Bibliography and Index to Climate*, Essay i., p. 9, is an attempt to explain the phenomena on the accepted theory 'that each element of climate is liable to a regular daily change primarily dependent on the earth's rotation and the consequent exposure to the sun, . . . and, lastly, that when heat alone and heat acting by the agency of aqueous vapour co-operate, the maximum effect produced by each separately is so counteracted by the other that the combined result of their co-operation is to produce a minimum effect, while the maximum occurs when each is at its mean and both

[1] International Science Series, volume *Weather*, p. 200.
[2] *Ibid.* p. 231.

act together; the result of which is an apparent double maximum in the course of the day.' The passage closes with the enigmatical remark: 'The maze of changes may seem very confused; but, in reality, however complicated the arrangements are, all is in perfect order.'

The fact really is that not one cause, but two great causes, are at work:

1. Solar heat, which, if acting alone, would vary in the same way from year to year, giving a periodicity as regular as day and night;

2. Solar and lunar attraction, the former of which varies in a regular manner during the year, and the latter of which varies irregularly owing to the moon's perturbations.

More than seventy years ago Mr. W. C. Redfield, a naval architect of New York, who is worthily acclaimed for his services to sea-going humanity, in observing the motion of storms and in deducing their course from many observations, nearly stumbled on the true solution of their causation. He proved that the winds of a storm-system have a well defined motion of revolution, while, at the same time, 'the whole whirl moves bodily onward in much the same way as eddies in a tidal river.'[1] By the use of this simile Mr. Redfield was working towards a larger conception of meteorological causation, and coming more nearly into relation with a fundamental law than, it is clear, he knew.

[1] *Marine Meteorology*, W. Allingham, pp. 77, 78. Mr. Allingham employs the highest possible terms of praise of Mr. Redfield, who is declared to have demonstrated practically what hitherto had been mere assumption. Redfield did somewhat the same for storms as Kepler did for astronomy. Modern weather-workers have merely amplified his method of investigation, aided by the electric telegraph, and steam as a motive power. Redfield collected extracts from ships' log-books relative to weather. He then laid down on large working charts, in geographical position, the data thus obtained. In this way he proved beyond cavil that the winds of a storm-system have a well defined

In ordinary circumstances winds apparently are not so directly the product of the moon's attractive force as are other phenomena dependent upon changes in the atmosphere. Or, rather, it would be more correct to say that investigation has not yet proceeded far enough to justify the drawing of definite conclusions as to ordinary winds, though, of course, winds are as certainly the product of the attractive power of the moon, daily exerted, combined with solar influence and local circumstances, as the eddies in a tidal river are the product of the tides, themselves the children of the moon. Nevertheless Mr. Clements has had some surprising successes in regard to wind-predictions.

In regard to great storms and the 'pull' of the moon exerted at its maximum, it may here be stated, the connexion of the sun, moon, and earth with visible phenomena is no more intimate than in other respects already considered, such as earthquakes and volcanic eruptions, and in others yet to be considered. But it is no less; moreover it is exactly in line with them; it differs only in degree, and not at all in essentials for ordinary winds.

Gales and storms occur in every part of the world at all hours of the day. Great storms may take place irrespective of the time at which the moon crosses the meridian, but it would appear from Mr. Clements' researches into the *rationale* of gales during the last twenty years that more storms occur when the moon transits the anti-meridian at midnight or thereabouts. The reason for this is that her force is then added to the

motion of revolution; while, at the same time, the whole whirl moves bodily onward in much the same way as eddies in a tidal river. On this imperishable foundation of observation he built up *The Law of Storms*. With Mr. Redfield must be mentioned an even earlier worker in the same field, Mr. Espy, who did for land-storms what Mr. Redfield did for storms at sea, and at a slightly earlier period. (See art. in the *North American Review*, May 1902, by Professor Cleveland Abbe, of the United States Weather Bureau).

force of the sun, and together the combined forces produce a larger nadir tidal effect than usual upon the atmosphere, the ocean, and the earth's crust. When the moon crosses the meridian of London or of any other place at such time as the sun is setting, the two orbs work together to produce a great lifting tidal effect, their forces meeting at an angle of 45°, producing gales such as those in the United Kingdom of March 26, 1882, December 28, 1900, January 27, 1901, the latter with a pressure of thirty-four pounds to the square foot, to mention only those which have been the subject of special consideration.

When the moon transits the meridian with the sun they pull together, and, in certain circumstances, cause great atmospheric disturbance. Again, when the moon transits the meridian about nine o'clock in the morning she is at an angle of 45° with the sun, and, in special circumstances, gales occur.

When the moon crosses the meridian at other times, and under other aspects, the movements of the atmosphere vary from a dead calm to something less than a gale.

Great gales take place about the time when the moon transits the meridian M at noon or the anti-meridian at midnight, for then these luminaries are pulling together at or near the time of new or full moon (Fig. 35).

When the moon transits the meridian M or the anti-meridian N about the time of sunrise or sunset, it gets into the positions B, C, D or F, at an angle of 45° from the meridian or anti-meridian, when the sun, at an angle of 90° with her, is respectively in the position C, B, F or D, so that their maximum combined pull takes place at L (denoting London or any other place), producing a zenith or nadir great aerial tide as the case may be. There are also gales when the moon transits the meridian or anti-meridian and the sun is at B and D respectively

at an angle of 45°, the effect being in these cases due to the moon and the sun alternately; the lunar effect increases as the solar effect decreases, and *vice versa*.

A. Gales are produced about the times of new and full moon;

B. near the times of the moon's quarter;

C. when the moon is at an angle of 45° with the sun, crossing the meridian about 9 p.m. or 9 a.m.; and

D. when the moon is at an angle of 45° with the sun, crossing the meridian about 3 p.m. or 3 a.m.

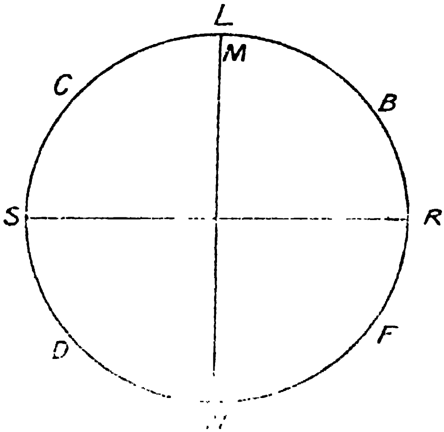


FIG. 35.

At A and B positions the sun and moon co-operate in producing gales, but at C and D positions the moon and sun are alternately active and passive.

(*a*) Gales when the moon crossed the meridian about noon and near midnight.

Date.	Force of wind in lbs. pressure on sq. foot	T.	P.	M. Dec.	S. Dec.	Difference.		Bar.
28/8/88	21·0	—	54·13	14°5′N	9°28′N	4·37	23·33	29·54
24/10/82	29·0	10·11	60·51	6°16′N	11°49′S	5 33	18·5	28·96
	Differences . . .		6·38			0·56	5·98	0 58
	Value .	about 2	·20			·8	·44	

2 + 20 + 36 = 58 = bar. difference.

Date.	Wind force in lbs. per square foot.	T.	P.	M. Dec.	S. Dec.	Difference.		Bar.
16/11/95	21·0	—	59·6	22°37′	18°45′S	3·52	41·22	29·57
12/12/83	26·5	10·45	60·48	18°5′N	23°5′S	5·0	41·10	29·71
Differences . . .			1·42			1·8	0·12	
Value .		about 1	5			−9	+1	

10+5−1=14=bar. difference.

12/4/96	22·5	—	54·2	9°22′N	8°58′N	0·24	18·20	29·69
19/1/01	22·6	—	57·41	19°5′S	20°25′S	1·20	39·30	29·39
Differences . . .			3·39			1·44	21·10	0·30
Value			−11			−14		

14+11=·25=bar. difference nearly.

12/4/96	22·5	—	54·2	9°22′N	8°58′N	0·24	18·20	29·69
13/4/00	20·0	11·9	54·21	8°39′S	8°59′N	0·20	17·38	29·60
Differences . . .			0·19			0·4	0·42	0·09
Value .		about 2	1			½	+6	

2+1+6=·09=bar. difference.

19/1/01	22·6	—	57·41	19°5′S	20°25′S	1·20	39·30	29·39
5/12/00	23·5	11·25	59·38	21°2′N	22°21′N	1·19	43·23	29·35
Differences . . .			1·57			0·01	3·53	0·04
Value .		about 2	6			0		

6−2=·04=bar. difference.

27/12/98	29·8	12·2	54·7	23°29′N	23°19′S	0·10	46·48	29·37
16/3/96	27·5	1·27	54·3	11°3′N	1°25′S	9·38	12·28	29·59
16/4/00	19·2	13·27	55·29	19°28′S	10°3′N	9·25	39·31	29·77
5/3/01	27·5	12·33	54·30	1°5′S	6°12′S	5·7	7·17	29·48
17/10/83	20·5	13·25	60·50	16°53′N	9°14′S	7·39	26·7	29·93
6/4/87	20·5	11·0	61·11	2°55′N	6°26′N	3·31	9·21	29·64

(*b*) Gales that happened near the time of the moon's quarters :

26/3/82	29·0	6·19	55·19	20°0′N	2°17′N	17·43	22·17	29·40
28/12/00	27·0	5·34	59·8	4°55′N	23°18′S	18·33	28·13	28·97
Differences		0·45	3·49			0·50	5·56	0·43
Value . .		1	11			−7	−48	
						−55		

55−11−1=·43=bar. difference.

29/11/97	26·0	4·53	58·6	12°52′S	21°35′S	8·43	34·27	29·45
23/8/82	28·0	7·16	57·40	20°45′S	11°24′N	9·21	32·9	29·22
Differences		2·23	0·26			0·38	2·18	0·23
Value . .		5	1			−5	+18	
						23		

23+5−1=27 / 23+1−5=19 =23=bar. difference.

27/1/01	34·4	6·10	58·59	16°47′N	18°33′S	1·46	35·20	29·17
3/8/00	27·0	5·45	55·1	17°28′S	17°34′N	0·6	35·2	29·21
		0·25	3·58			1·40	0·18	0·04
		1	12			+14	+3	
						17		

17−12−1=·04=bar. difference.

30/12/00	20·0	7·18	54·17	14°24′N	23°11′S	8·47	37·35	29·30
29/1/83	21·5	17·0	54·19	11°52′S	17°56′S	6·4	29·48	29·34
17/5/99	23·2	6·10	54·23	8°23′N	19°20′N	10·57	27·43	29·71
18/11/93	18·0	7·39	57·18	5°43′S	19°21′S	13·38	25·4	29·01

(*c*) Gales when the moon crossed the meridian about 9 a.m. or 9 p.m. :

Date.	Wind lbs. pressure.	T.	P.	M. Dec.	S. Dec.	Difference.		Bar.
11/11/91	31·5	8·15	59·58	7°34′S	17°26′S	9·52	25·0	28·58
29/4/82	49·5	9·21	54·33	4°0′S	14°31′N	10·31	18·31	29·00
		1·6	5·25			0·39	6·29	0·42
		2	16			−4	+52	
						56		

56 + 2 − 16 = 42 = bar. difference.

20/3/2	20·0	9·34	57·29	10°1′N	0°24′S	9·37	10·25	29·19
6/8/00	24·3	8·20	57·20	22°5′S	16°40′N	5·19	38·51	29·30
30/3/01	18·0	9·5	55·15	8°58′N	3°36′N	5·22	12·34	29·04
31/3/86	27·6	21·50	54·24	8°33′S	4°14′N	4·19	12·47	29·44

(*d*) Gales when the moon crossed the meridian about 3 a.m. or 3 p.m. :

	Wind pressure.	T.	P.	M. Dec.	S. Dec.	Difference.		Bar.
13/2/99	33·4	2·51	58·58	8°18′S	13°19′S	5·1	21·37	29·09
27/1/83	28·0	15·35	54·13	4°0′S	18°28′S	14·28	22·28	29·38
5/12/95	23·7	15·24	58·35	22°21′N	22°23′S	0·2	44·44	29·41

A concrete example, with details, will show how the various forces work to produce calamity, such as happened at Galveston, Texas, on September 8, 1890, when a great wind-storm and a huge tidal wave worked dire destruction alike to life and property. Between six and nine o'clock at night (says one record), nothing was seen from the island but one unbroken circle of sea. The angry currents lashed the wharves and poured into the streets; the wind howled and shrieked, making an uncanny uproar that brought fear into the bravest hearts. Men hid in their homes or groped in the dark in the streets, breathlessly watching in the distance the tiger leaps of the mountainous waves. The streets were deserted an hour after the storm struck the city, but when the more lightly built houses began to totter some of the inhabitants came into the streets again. Men

tied their wives and children to them with ropes, and stood in the open, dodging the flying timbers and the elements. The streets rapidly became flooded, and shutters and doors were cut down in many places with axes, and used as rafts. Meanwhile, everywhere were heard the cries and shrieks of women and children, and even those of stout-hearted men. Ever fiercer howled the wind, ever greater became the flood. Men were drowned in sight of each other; the heavens grew darker, and the breakers could be heard roaring in the streets. Rain fell in torrents. Men and women stood on the rafts and prayed. Some succumbed and fell lifeless into the waters. The houses bordering the sea-front could be heard crashing to destruction, together with the cries of the dying, mingling with the weird screeching of the gale.' It is stated that no fewer than ten thousand lives were lost, while fifteen thousand persons became homeless.

It may now be seen whether, taking all the known facts into account, the problem of the Galveston disaster can be adequately explained on the Clements theories. The earth itself could be only a passive agent acted upon by internal or external agencies. Already it has been demonstrated in these pages that the internal forces of the earth only become exerted when subjected to outside influences. In a word, the earth is an object, inert in itself, and only active as played upon by outside agencies. Nothing but some such mighty influence as is herein postulated could cause such a disaster as that at Galveston. The power required was a force able to raise the waters of the Gulf of Mexico fifteen feet above high-water level, and to sweep over the coast-line into the adjacent country. In addition, the atmosphere had to be so powerfully moved as to cause a tornado-like wind to rush at the rate of one hundred miles an hour over a wide area of sea and land. Such destruc-

tive forces were let loose as no combination of the power of man could produce, and which even the imagination can hardly realize.

The stars are at such inconceivable distances from the earth that they can have no effect in bringing about a catastrophe on such a scale, and even the planets that are near in comparison may be left out in consideration of the problem, as when they are all pulling together at a maximum, their effect is not quite one-eightieth of that of the moon. We know that the tides are produced by the moon and sun, principally the former, so that these are the only bodies we can look to for an explanation of the mystery. The question is, Are

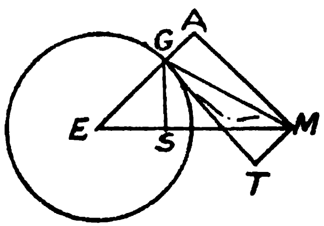


FIG. 36.

they sufficiently powerful to produce such a disaster as that at Galveston? Let us for a moment consider the question. The tides are raised by the moon about six feet. How is this done? It is evident that the moon cannot pull up the water directly underneath it at a point S on the earth's surface, because the earth's gravity there pulls the water, air, and solid part with eleven million times the force; in fact, the moon's pulling up force directly underneath is only then seven hundredths of an inch—an altogether inappreciable amount. But at G, Fig. 36, at an angular distance of 45° on the earth's surface from a point directly under the moon, the moon pulls up the water to a distance of five feet ten inches in the direction of G M, the letter M representing the

moon's position. The force G M is resolved into the two forces of G A and G T, so that G A has no effect; it is pulling directly against gravity, but G T being at right angles to gravity is unopposed by it, so that the water is raised by the pull from the moon M on G,—Galveston or any other place,—to about six feet.

Were Galveston and its vicinity at the time of the occurrence of the disaster at this angle of 45° from the moon and sun when their greatest pull is exerted? On the 8th September, the sun, denoted by S, Fig. 37, was 5¾° north of the equator A E B, and the moon was about the same distance south, so that the nadir tide of the

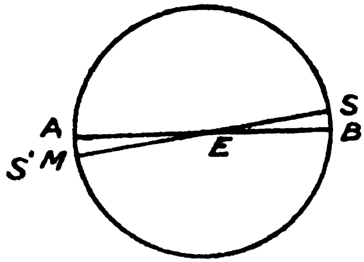


FIG. 37.

sun would be with that of the moon, acting to the south of the equator.

At noon on the 8th the sun was in Right Ascension 11h. 6m., and 5°46′ north of the equator, but taking the point S′ opposite to S in Fig. 37, the nadir position of the sun was R. A. 23·6 and 5°46′ south.

The sun for a few hours would be practically stationary about the point S, Fig. 38; from this point draw a circle S′ S′ S′ S′ with an angular distance of 45°, and successive circles with the same angle of 45° drawn from M 7·20, M 8·6, and M 8·12 will cut the sun's circle at M′ 7·20, M′ 8·6, and M′ 8·12, but 8·12 Greenwich time is midnight, equivalent to 8·6 evening at Galveston, so that a circle from the moon's position cut a similar

circle from the sun's position at an angle of 45°, just about the time the disaster took place.

The scale of Fig. 38 is given at the top in degrees and time, and at the sides for degrees north of the equator, 0° to 40°. At noon at Galveston, corresponding to 8h. 6m. Greenwich, the combined lunar and solar tides occurred at 3° W. long., and 38° N. lat., and just before 8·12 Greenwich, corresponding to 8·6, or six o'clock in the evening, the combined maximum lunar and solar

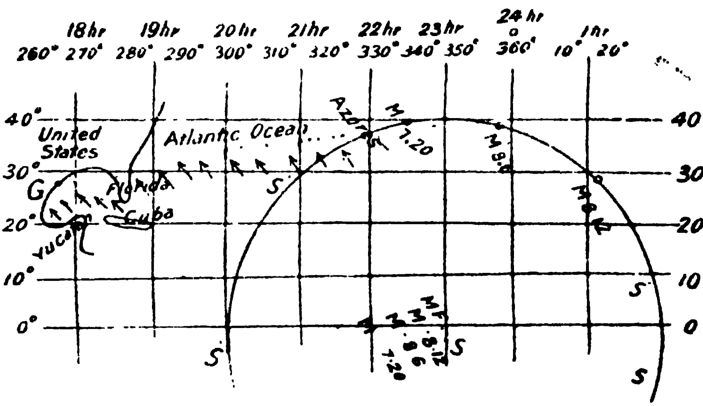


FIG. 38.

tides were together at G, denoting the position of Galveston on Fig. 38; the earth moving from west to east brings the position of Galveston up to the position marked M′ 8·12. In other words the maximum lunar and solar forces during the six hours from noon at Galveston to 6 p.m. moved along the dotted line from the Spanish Peninsula, by way of the Azores, across the Atlantic Ocean, through North Florida to Galveston, and there, for the first time, encountering serious opposition to its progress by the land round Galveston, and its escape being barred in every other direction by Florida, Cuba, and Yucatan, wave after wave was in quick succession thrown up against the coast, under the now (about six o'clock) powerful combined maximum pull of

moon and sun at an exact angle of 45°, so that water to a depth of fifteen feet was thrown over Galveston, due to the highlands to the north-west and west. The progress of the lower stratum of air was also, but to a less extent, barred, the result being that a partial vacuum due to the great outward pull of the moon and sun, was suddenly produced, and this assumed an extremely rapid rotary motion, at the rate of probably upwards of one hundred miles an hour, owing to the fact that the moon was rapidly moving in the direction of full moon, and this was considerably amplified at an angle of 45° at M′ 8·12, Fig. 38.

An examination of Fig. 38 will show that while the earth moved due east along the parallel, 10°, 20°, 30° to 90° in six hours from noon at Galveston to six p.m., the combined lunar and solar wave only moved 19° from M′ 8·6 to M′ 8·12. Now representing the easterly direction of the earth during six hours from A to B, Fig. 39, and the south-easterly direction of the combined lunar and solar tide at an angle of 45° by the line A C,

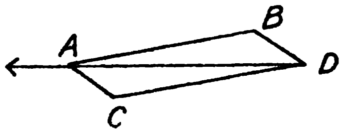


FIG. 39.

we have the resultant direction of the water in the line from A to D, but as this tide would be dragged at an angle of 45° after the sun and moon in a westerly direction, the combined wave would proceed in the direction of the arrow from D to A. The lunar and solar tide travelling across the Atlantic Ocean, as represented by the dotted line in Fig. 38, would be impelled, as indicated by the arrows, in a north of westerly direction, and this pressure in that direction in the open ocean would meet with little obstruction, there being no obstacle to the

flow of the water. When this wave came near the United States' eastern coast the wave would be simply headed off in a northerly direction without much arrestment to its progress even, until the wave struck the east coast of Florida, but immediately it reached the west coast of Florida the turmoil began. The water of the Gulf of Mexico was barred in its northerly progress by the land and ran quickly along the coast to the mouth of the Mississippi; as the pressure of water from behind, running from between Cuba and Florida decreased, it quickly flowed in the direction of Galveston, where its progress westwards would be stopped by waves proceeding from the north and west of Yucatan, the result being that towards Galveston, from its peculiar situation, water would flow from every direction, until the culmination-point, just before six o'clock, when the combined great tidal effect at an angle of 45° from the position of the moon and sun was directly over the doomed city, producing a great updraught in the air, causing a partial vacuum, to which centre there would be a rush of water from all directions, and as there was no means of ready escape, the wave was simply heaped higher and higher, until the luni-solar energy had exhausted itself, and had passed across Central America into the Pacific, where the wave would be again practically unopposed in the free ocean.

In Fig. 40, if we take G to represent Galveston, the sun S would be overhead at noon, the moon being opposite at M. At three o'clock the sun would be at S′, with the moon M′ opposite, its nadir effect aiding that of the sun, so that under this condition the moon and sun, at an angle of 45° from Galveston, would exercise their maximum effect; but as at that time the influence of the moon and the sun were at a maximum in the mid-Atlantic (Fig. 38, hour 21), it was not at its possible greatest until about six o'clock, when the combined

lunar and solar wave suddenly travelled up and reached Galveston. Now the turmoil was at its height. Tremendous waves in rapid succession were thrown against the town, a great vacuum was formed, and the air rushed in from all directions; during the time of the short coalescence of the lunar and solar waves at an angle of 45°, the air, due to the rotary movement of the lunar wave round that of the practically stationary solar wave, was rotated round the centre at Galveston

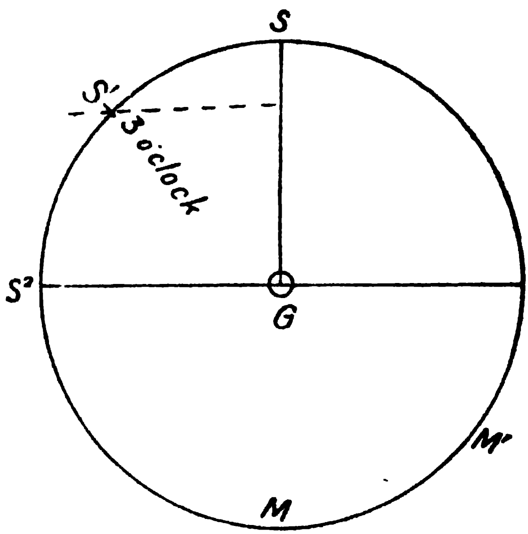


FIG. 40.

at, as has been already stated, a rate of over one hundred miles an hour.

The disaster was due

(1) to the north of westerly trend of the water in the Gulf of Mexico, as explained by Fig. 38;

(2) To the land-barrier preventing the progress of the water, and there being no escape for it in any way;

(3) To the coincidence of the occurrence of the lunar-solar waves at an angle of 45° at or about the time of sunset, when the maximum effect of the sun at an angle

of 45° at three o'clock has increased after three hours and has attained its maximum at a time when the moon is full or new. In this case the moon was within six hours of its full phase, and within nineteen hours of perigee. The inauguration of a decreasing and minimum force at sunset s^2 and the rapid progress of the luni-solar wave in a S.W. direction brought the hurricane to an end before midnight, when the sun was in the position M, Fig. 40.

It seemed to me, in this connexion, that the investigations of Mr. Clements might be carried much farther into detail. I, therefore, invited his attention to Chapter XI, 'Hurricanes: Seasons and Storm-Tracks,' in Allingham's work on *Marine Meteorology*, already referred to. The consequence of my doing so has been the preparation of the following data, which, alike for comprehensiveness, intrinsic merit, and interest, call for the special consideration of the reader. To make the data more plain I quote several passages from Allingham's chapter, the publishers, Messrs. Charles Griffin and Co., Ltd., having courteously permitted me to do so. The passages I cite are as follows:

'Very little reliable information is obtainable with respect to cyclones in the South Atlantic. Sufficient seems known, however, to confirm their existence and to show that they follow much the same laws as cyclones in the South Indian Ocean, although more remote from the equator. Fig. 15 shows the track of a Norwegian barque, the *Dagny*, Captain Olsen, from June 27, 1891, to July 26, 1891, while on the passage from Leith to Buenos Ayres. On July 1 she fell in with light variable winds, which held for eleven days; then the wind came out with hurricane violence from the north, and she was run before the gale under bare poles. As the wind shifted to north-west, west, south-west, south, and south-east, little by little, her course was altered so as to bring the wind right aft. She thus ran round the circum-

ference of a circle, and, ten days after the cyclone struck her, had arrived at the position whence she kept away before the gale. This cyclone was evidently moving to the south-east; and, by manœuvring to keep the wind aft, the vessel decreased her distance from the centre, as evidenced by the decreasing wind and rising barometer. Fig. 16 affords data of a cyclone experienced by the British barque *May Hulse*, Captain H. Youlden, in November, 1882, which was entered in lat. 26°23′ S., 39°27′ W. long., at noon of the 27th, and cleared at midnight of the 28th, in lat. 28°30′ S., long. 41°15′ E. The fall in the barometer reading was slight, but at 8·30 a.m. of the 28th the wind shifted suddenly to S. by W., and increased rapidly to gale force. This cyclone was also travelling south-eastward. On December 16, 1897, the *Danube*, Captain Dickinson, in lat. 32° S., 51° W. long., experienced a small cyclone, although the barometer only went from 29·8 inches to 29·5 inches and back. Very heavy thunder, lightning, and rain, with wind strong from N.W., prevailed for a short time, then the rain ceased, and calm intervened, followed by a moderate gale from S.E. It would appear that the South Atlantic cyclones travel west in about 20° S. lat., recurve near the coast of Brazil, and thence proceed to the south-eastward. Captain A. P. Pinheiro, Chief of the Meteorological Service of the Brazilian Navy, Rio Janeiro, in a short paper read at the Chicago International Meteorological Congress, 1893, stated that during a period of twenty years he had noticed that South Atlantic cyclones of the higher latitudes travel from the Pacific, or Brazil, to the eastward. North Atlantic cyclones of higher latitudes not infrequently reach the ocean from the continent of North America, in a similar way.

'The storms of the east coast of South America have recently been investigated by Dr. E. Knipping, of the *Deutsche Seewarte*. During the period 1890–96 inclusive, sixty-six (66) storms, all giving rise to winds of hurricane force, were reported as occurring between the parallels of 30° S. and 40° S., the latitude of the mouth of the La Plata. Forty (40) of these were encountered by outward bound vessels, twenty-six (26) by homeward bound, showing that storms are of greater frequency along a belt within 500 miles of the coast, wherein the track of outward bound vessels lies, than along the more outlying homeward bound track. The monthly distribution was as follows:

Jan.	Feb.	Mch.	Apl.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
3	0	1	7	5	12	14	6	7	4	4	3	66

'A comparison of the number of easterly and westerly storms during the several months shows that during the nine months September–May inclusive, the former were just as frequent as the latter, the same number of each, viz., seventeen (17) having been reported; throughout the winter different conditions prevail, for of the thirty-two (32) storms reported as occurring during June, July and August, four (4) were easterly, and the remaining twenty-eight (28) were westerly. The easterly storms are therefore about uniformly distributed throughout the year, while the westerly storms show a marked increase in frequency during the winter months.

'Of the sixty-six (66) storms, seventeen (17) were from the N.E., four (4) from the S.E., sixteen (16) from the S.W., and twenty-nine (29) from the N.W.

'The average shift of the wind from the beginning to the end of the storm amounted in the N.E. storms to nine (9) points, almost without exception round by the left; in S.E. storms to seven (7) points, round by the right (E.S.E. to South) in S.W. storms the wind generally held steady, the average shift being almost nothing, the record showing two cases of shifts to the left of four (4) points each, and two others of shifts to the right of like amount; in N.W. storms the average shift was six (6) points to the left. Rapid shifts, i.e., shifts of four (4) points or more within an hour, were noted only in N.E. storms, seven cases being reported, six of these to the left. In one instance the direction could not be determined. The maximum shift observed was fourteen (14) points in fifteen (15) minutes.

'Dr. Meldrum, of Mauritius, is the most reliable authority for cyclonic storms of the South Indian Ocean. In 1885 he laid before that year's British Association meeting a series of cyclone track-charts for that ocean from 1856 to 1884. Dr. Meldrum's more extended researches, extending over the 38 years, 1848 to 1885, were published by the British Meteorological Office in 1891. An attempt was made to divide the storms into progressive and stationary cyclones. This distinction is but ill defined. The cyclone season of the South Indian Ocean is from November to May, although an occasional storm may be fallen in with in June, July, September

and October. Cyclones seldom, if ever, vex navigators in that ocean during the month of August. The maximum frequency of cyclones occurs there from December to March. Hence bad weather is most probable about the period when the sun's southern declination is greatest.

'As a general rule cyclones of the Southern Indian Ocean have their vertices and recurvature between the twentieth and twenty-second parallels of south latitude, although they may extend to 8° S. and 32° S. They originate somewhere along the tenth parallel of south latitude. Proceeding thence towards the south-westward along a track trending more southerly, they eventually travel due south and south-east. Dr. Meldrum's track-charts show that about ten per cent. of South Indian Ocean cyclones originate between the fourth and ninth parallels of south latitude, and generally between the eightieth and ninetieth meridians of east longitude. It is often assumed that cyclonic storms do not put in an appearance near the equator in any ocean. Dr. Meldrum, however, gives examples of so-called stationary cyclones which were experienced by vessels on, or near, the equator in the Indian Ocean. One was directly on, and four others within two degrees of, the equator. Mr. W. L. Dallas, Assistant Meteorological Reporter to the Government of India, believes that he has traced a cyclone from lat. 1° S., 91° E. long., on December 5, 1894, across the equator, and northward to 21° N. lat., 89° E. long., on the 16th.

'Some writers imagine a higher velocity for these storms in their initial stage, but Dr. Meldrum's tracks are not in exact agreement with this view. Not infrequently the storm is moving more rapidly when several days old than it did soon after formation. The rate of travel for Southern Ocean cyclonic storms is comparatively slow throughout, and very variable. A daily advance of 500 miles is unusually rapid, while 150 to 200 miles is the average daily rate.

'The hurricane season in the South Pacific is from December to March, with an occasional extension into April. March is the month of maximum cyclone frequency. These storms generally originate in the area bounded by a line drawn from the southern extremity of New Caledonia to the Samoan Islands, and another, almost parallel, line about 350 miles distant through the islands of Rotuma, Mallikola, and Oatafu. Within nine degrees of the equator cyclones are unknown.

When the rainy season is either late, or interrupted by a persistent spell of dry weather, a hurricane may safely be predicted. Continuous heavy rain generally heralds the storm. To the right of the storm track the S.E. trades gradually freshen to gale force; whereas to the left of the track the trades shift to east and north-east, with squalls and gloomy weather. The barometer falls slowly and irregularly. A slight rise sometimes occurs before the minimum pressure which marks the passage of the cyclone centre. Nearer the equator the onward motion is about two miles an hour, whereas in higher latitudes, as 30° S., it may reach twenty miles an hour. When passing over the island groups cyclones become almost stationary.'

COMMENTS UPON THE CHAPTER ON HURRICANES IN ALLINGHAM'S 'MARINE METEOROLOGY'

The storms of the east coast of South America occur between the parallels of 30° S. and 40° S., the latitude of the mouth of the La Plata. During the period 1890–96 Dr. E. Knipping, of the *Deutsche Seewarte*, investigated sixty-six such storms. Forty were encountered by outward bound vessels, and twenty-six by ships homeward bound, showing that storms are of greater frequency along a belt within five hundred miles of the coast, wherein the track of the outward-bound vessel lies, than along the more outlying homeward-bound track.

All these storms can be shown to occur when the angular distance of the cyclone is about 90° from the moon and about 60° from the sun, or *vice versa*. There are more storms in June and July, because the sun is not far from the moon on the ecliptic. The storms are projected from 30° to 40° south, because from the ecliptic 23½° north an angle of 60° gives an interval of about three hours before or after noon for the sun's position, and of five hours for the moon's position, and *vice versa*. As the moon is 23½° north and south of the equator within 5° more or less every month in the year, the moon will several times each month make an angle of about

90° or 60° with all places lying between the parallels of 30° or 40° S., but there can be no cyclone unless the sun makes an angle of 60° or 90° at the same time, and that does not often occur, excepting in June and July.

The latest information with respect to cyclonic storms of the South Pacific is afforded by the sub-chart of the United States Pilot Chart for December 1895. Of the fifty-five South Pacific hurricanes, thirty-two seemed to move in a straight line to the south-west, and twenty-two followed a parabolic track, and one was very irregular. The vortex of the parabolic track is approximately in 20° S. lat. The hurricane season in the South Pacific is from December to March. March is the month of maximum cyclone frequency. With the sun over four hours from the meridian of the centre of the storm, we have along the parallel of 20° south latitude an angle of 60°, and at an angle of 90° the moon would be at or near the ecliptic, 23½° north, and upwards of four hours from the meridian. There are more storms in January, because during that month the average declination of the sun is 20° S. During March the average declination of the sun varies from about 7° S. to nearly 4° N., and if we take 5° from the equator as the average one-hour angle of three hours the angular distance of 45° goes about 20° south, near the position of the moon when most northerly or southerly.

'Within nine degrees of the equator cyclones are unknown' (p. 91).

This has never, to my knowledge, says Mr. Clements, been accounted for. The reason why cyclones are unknown is that when the sun is on the equator and the moon about 23½° north or south or the moon is on the equator and the sun 23½° north or south or nearly so, the circles at 45° angular distances cut at more than 9° from the equator. Taking every possible position of the moon and sun it will be found that circles of 45° radius

from the positions of the sun and moon rarely if ever cut within 9° from the equator.

Typhoons occurring in the China Sea, in the neighbourhood of the Philippines, the Caroline and Ladrones Islands, between 10° and 20° north latitude are most numerous in September, because the sun is near the equator, when a circle from it at an angle of 45° is cut by a circle from the moon when about 23½° north, between 10° and 20° north from the equator.

Cyclones in the Arabian Sea (page 93) are few in number, and precise information is not always attainable. In the Bay of Bengal they are more frequently experienced, and occur especially on the western side of the Bay. In either case the most dangerous period is the changing of the monsoons. They are more marked in October, November, and the beginning of December, when the north-east monsoon sets in, than when the south-west monsoon becomes manifest in April, May, and June. There are, however, some notable exceptions to this rule so far as May is concerned. During that month several of the most disastrous cyclones known have occurred at Madras. The cyclone of May 1877 has been made the subject of a monograph by Mr. John Eliot, F.R.S., of the Indian Meteorological Department, which should take high rank for the thoroughness and luminousness with which a complex matter is dealt with. The Bengal Bay cyclones should be more numerous in October, because the 45° nadir moon circle cuts the sun's 45° circle, the centre of which is, on the average, 8° S. declination, about N. lat. 18° in the Bay. The West Indian hurricances are also most numerous in October for the same reason.

The South Atlantic Cyclone of July 1891 (Fig. 41).

Taking o o perpendicular line as the meridian of the place where the cyclone occurred, P represents the posi-

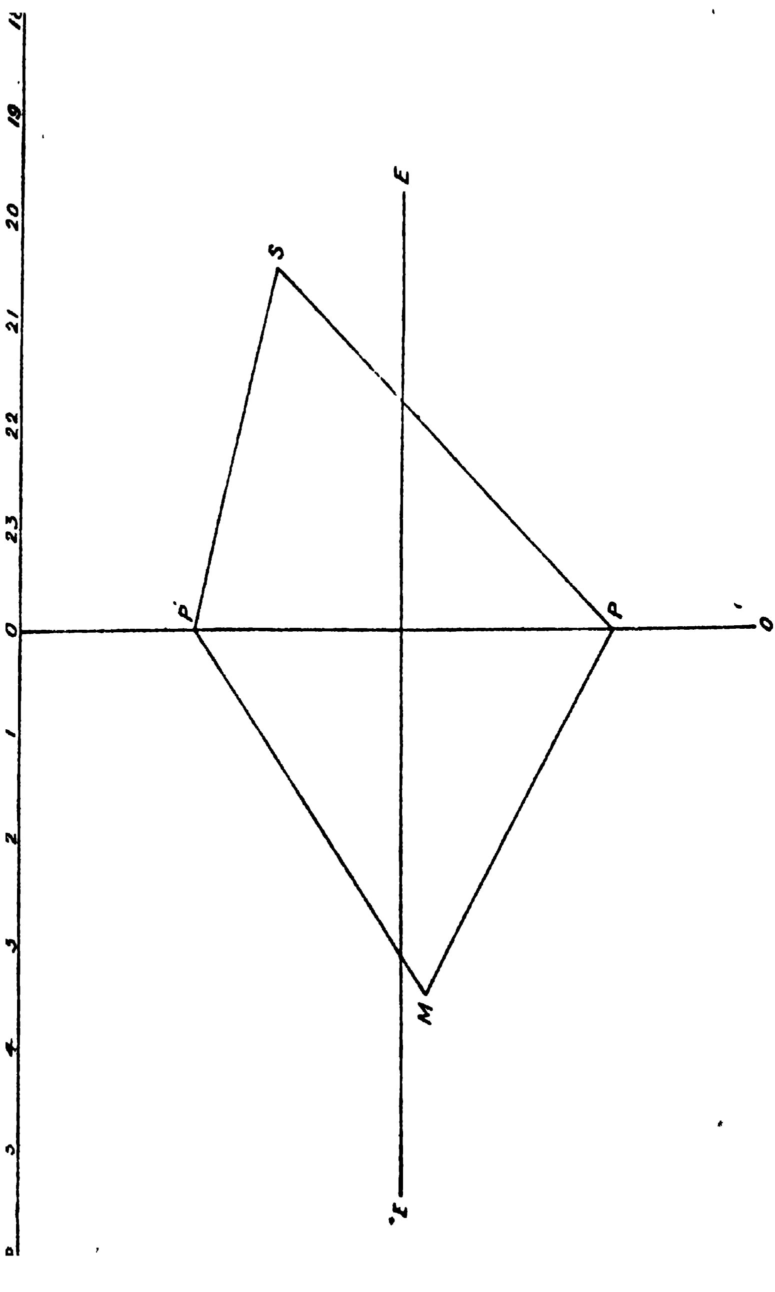


FIG. 41.

tion of that place, and P′ its nodal position on the globe, and E E the equatorial line. At the time the cyclone was at its maximum velocity the sun was about 22° N. at 8.30 a.m. on the 12th, or at 20h. 30m. astronomical time on July 11, 1891, while the nadir moon was nearly 5° S. declination, and was acting as if three and a half hours on the other side of the meridian from the sun. The sun was nearly 90°, while the moon was a little over 60° from the centre of the cyclone at P, the sum of the two angles being 150°, which is the average also for earthquake shocks.

The Norwegian barque *Dagny*, Captain Olsen, on her passage from Leith to Buenos Ayres, encountered a hurricane on morning of July 12, 1891, at 36° S. and 50° W. in the South Atlantic Ocean, off the mouth of the Rio de la Plata.

The cyclone which was experienced by the British barque *May Hulse*, Captain H. Youlden, on the morning of November 28, 1882, took place at the same time of the morning, 8h. 30m., as the cyclone of July 12, 1891, when the sun was about the same distance north as in this case it was south, 21°21′. In this case the moon was about 90° from the place of cyclone, P, and in the other case the sun was 90° and the moon was 68°, while in the case of the Norwegian barque the moon was nearly the same. O O is taken as the meridian of the place; 40°30′ E. to the S.W. of Madagascar (Fig. 42).

THE LONDON AND BRIGHTON GALE OF 1896.

The wind that destroyed the chain pier at Brighton on morning of December 5, 1896, was predicted by Mr. Clements. The gale in London took place about three o'clock on the morning of 5th. The sun and moon were close together at lower transit which occurred at 12·4, and the storm took place three hours afterwards, when

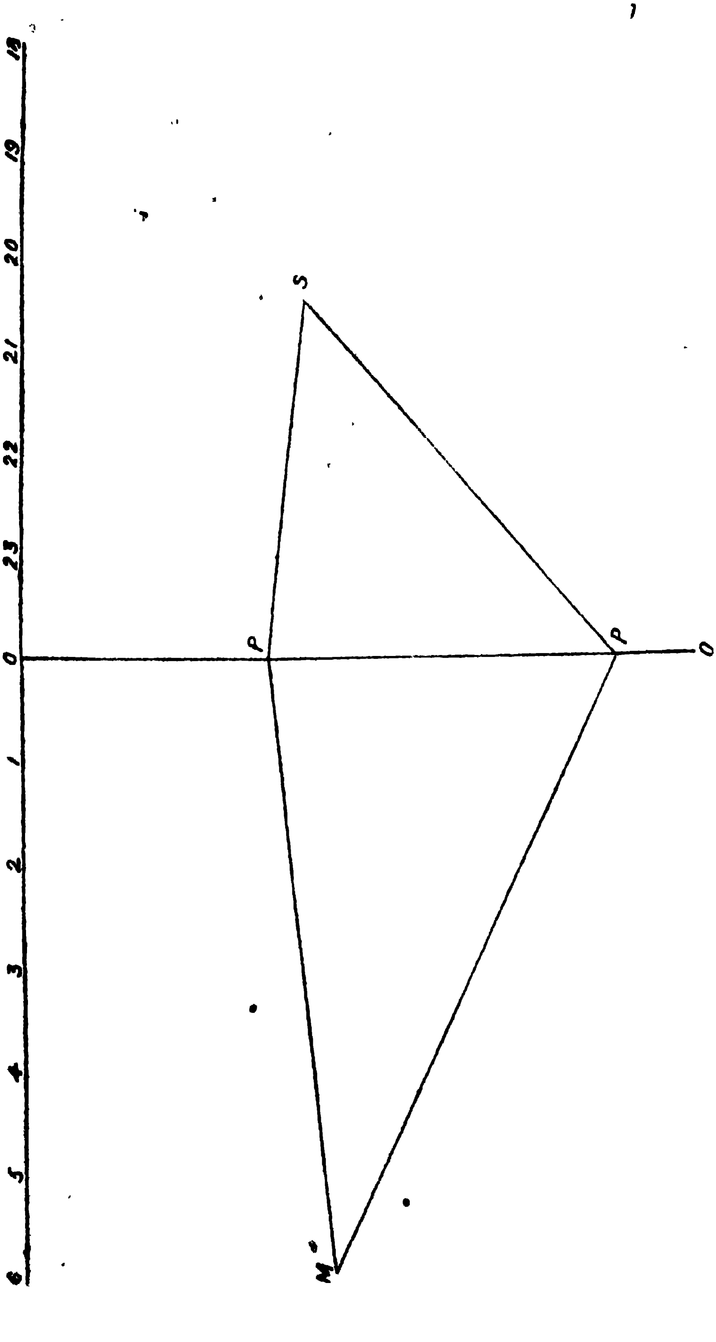


FIG. 42.

the moon and sun were close together at 15·4, their nadir tide acting at 3h. 4m. or about 45° from London, and the angular distance from London to 27°17′ S.; the position of the moon was exactly 90°, and the position of the sun 22°29′ S. was 80° at the same hour angle, these luminaries being together and exercising their maximum effect at those angles.

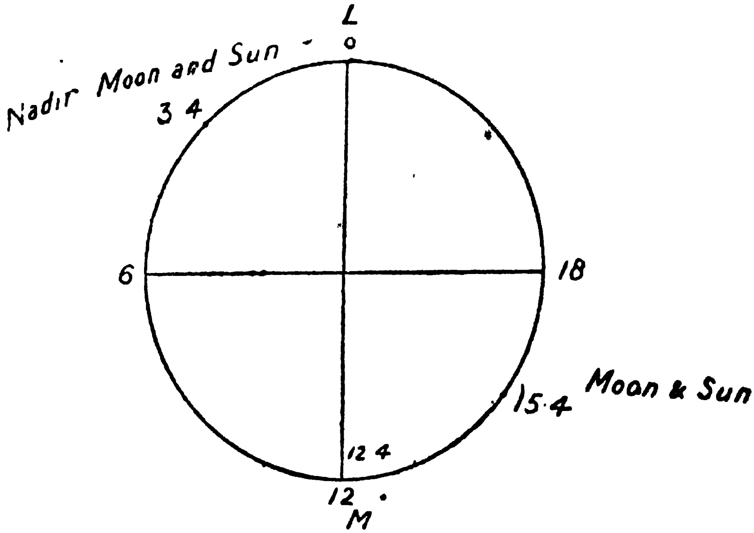


FIG. 43.

This storm was produced in exactly the same way as are earthquakes.

THE AUGUST STORM, 1900.

On the morning of August 3, 1900, there was a gale of wind after nine o'clock, taken as 21h. 22m. astronomical time on 2nd, the moon having transited the lower meridian at 17h. 22m. In these circumstances the sun has to be moved forward from 17h. 22m. to 21h. 22m. or through 4h., and of course the moon at M on lower meridian has to be moved forward to 16h. M′, the storm

being caused by the nadir tide at M″ 4h. From London to the moon's position at 16°22′ S. dec. is 90°, and to

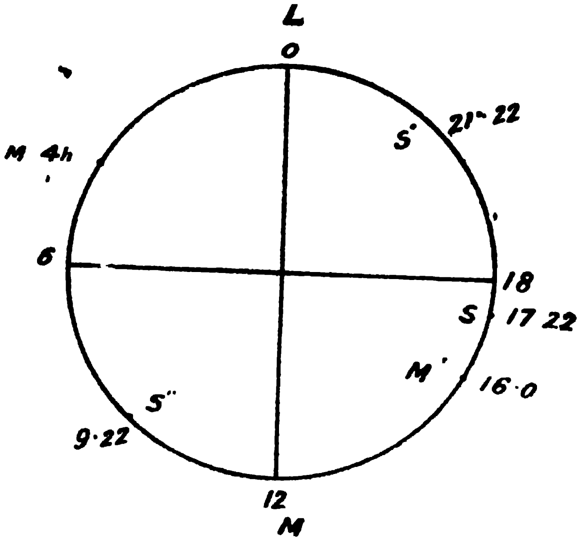


FIG. 44.

the nadir sun's position 17°34′ S, is over 70°. Thus, no matter what great storm be taken, the combined lunar and solar angle is on the average 150°.

A London Storm in 1902.

The storm at London, with a pressure of 27·3 lbs. to the square inch, on morning of April 27, 1902, took place when the sun was at 19h. 30m., and when the moon was at 4h. 14m. The moon at the time of the gale was 19°15′ S., and exactly 90° from London, at angle of 4h. 14m. or 63½° with the meridian and the sun located 13°30′ N.

was 62° from London. This gale also follows the same law, 90° and 62° being equal to 152°.

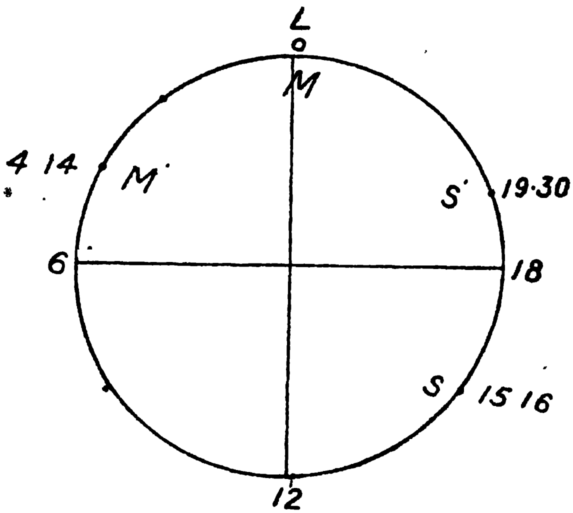


FIG. 45.

THE ALGOA BAY DISASTER, AUGUST 31, 1902.

Centre of gale, 34° S. and 26° E.

When the moon was on the meridian at 23h. 17m. on August 31, or 11h. 17m. on the morning of Sept. 1, the sun was 43m. or 10¾° E. of the meridian of 26° E., or 36¾° E. of Greenwich, and as the sun was 8°30′ north of the equator, the sun was at an angle of about 45° from the position of centre of gale, at 34° S. Thus 34° + 8°30′ = 42°30′, and as the sun, when the moon was on the meridian, was at an angle of 10¾°, the sun was at an angle of 45°, with Algoa Bay.

The moon, when on the meridian at 11h. 17m. on morning of September 1, was 8° N., and Algoa Bay being 34° S., there was an interval of 42° between the position of the moon and the Bay. When the sun was on the

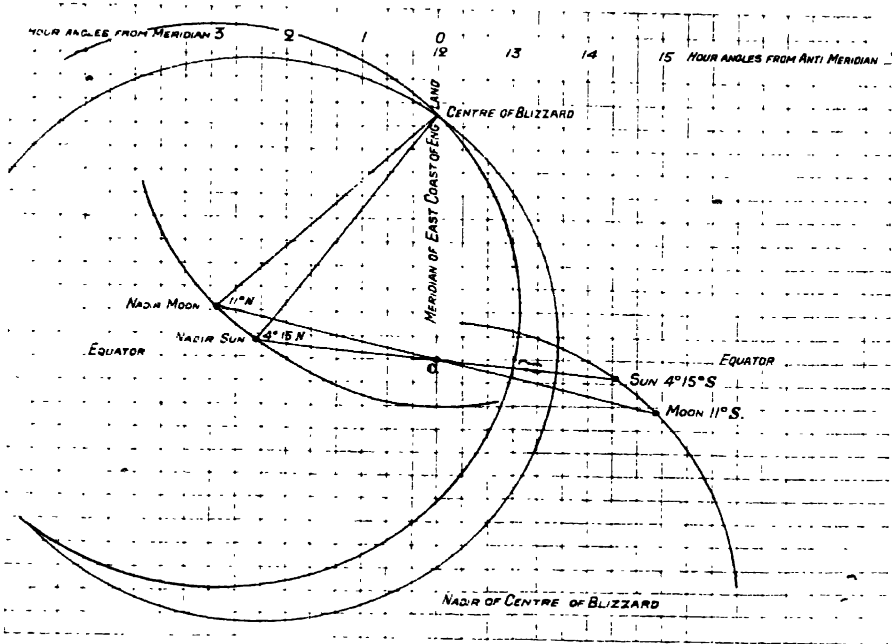


Fig. 46.
THE GREAT BLIZZARD, EASTERN ENGLAND, MARCH 1891

To face Page 179.

meridian on September 1, the moon was 10° west, and at noon was 45° from Algoa Bay.

The moon and sun on September 1 were nearly together in longitude, only 10° apart, and were roughly at an angle of 45° from the seat of the storm about noon, when the maximum combined lunar and solar effect was produced on the waters of Algoa Bay, and this effect continued, causing a maximum velocity of the air five hours after the moon's transit, when the moon was about 90° and the sun about 75° from storm area. (See Fig. 46*a*, on p. 180.)

The Great Blizzard in Eastern England in 1891.

A great blizzard was experienced on the East Coast of England on March 10, 1891, with much resulting destruction of shipping. In the figure, which faces this page, the meridian of the East Coast of England is given, the sun and the moon being at an angle of 60° from the nadir of centre of blizzard. A line from the points on the earth's surface directly under the sun and moon on the morning of March 10, taken through the centre of the earth, gives the nadir positions of the moon and sun from which positions circles at an angle of 60° cut, as shown in the figure, at the point of the centre of the blizzard. When the sun and moon are in conjunction, or opposition, or near each other, as in this case, the storm, great wave, earthquake, or other disturbance; is always produced at an angular distance of 60° or thereabouts from these luminaries.

The following diagram (Fig. 46*a*) will make the Algoa Bay position clear:

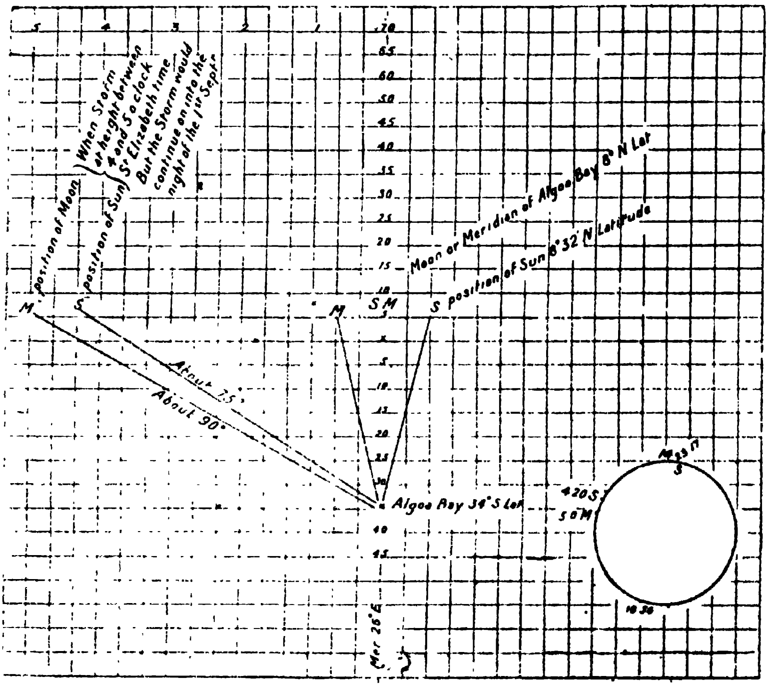


FIG. 46*a*.

CHAPTER V

Sun-Spots: Their Non-Relation to Rainfall and their Non-Connexion with Indian Famines

I. *The Solution of the Mystery of their Appearance.*

First English Astronomer to Trace Connexion between Sun-Spots and Weather Phenomena.
Polar or Equatorial Regions alone Suitable to Test the Connexion.
Norman R. Pogson, C.I.E., Imperial Astronomer at Madras, and Meteorologist for Southern India.
Mr. Pogson's Researches as Submitted to the Indian Famine Commission of 1878–79.
Differing Views of Sun-Spot Theorists.
Sir Norman Lockyer's Belief in Sun-Spots as Drought Indicators.
The Controversy of the Late Seventies and a Campaign of Discussion.
Sir Richard Strachey at the Royal Institution.
Sir William Hunter's Part in the Fruitless Campaign.
Sir Norman Lockyer's Theories emphatically of Faith and not of Works.
Prediction of Weather Phenomena by the Way of Spots Wholly Impracticable.
The Sun-Worshippers of Modern Times and their Complete Lack of Trustworthy Dogma.
Mr. Archibald's Failure to Fit Famines in with Sun-Spots.
American Meteorologists most Devoted of Sun-Worshippers. 'The Sun is the Cause. And, Why Not?'
The Sun's Alleged Magnetic Influence and its Supposed Potency on the Weather.
Some of the Defects of Sun-Worship.
Mr. Clements' Researches into the Causation of Sun-Spots.
Alineation of the Planets, including the Earth, the Real Cause of Sun-Spots.
De la Rue's Researches would have Led Him to the Truth, had they been Continued.
At Maximum Sun-Spot Periods Planets usually on Same Side of Sun as the Earth.
Great Sun-Spot Combinations in 1868, 1870, 1881, 1893 Due to Planetary Conjunction.

'The Planets Acting and Interacting with Each Other at an Angle of 45°' Produce Spots in the Photosphere.
In 1905 a Maximum of Spots will be Produced.

II. *The Non-Relation of Sun-Spots to Rainfall, and Their Non-Connexion with Indian Droughts.*

The Astronomical Inappreciation of Planetary 'Pull.'
Series of Diagrams Indicating Manner and Extent of Influence Exerted by the Planets.
Life of a Spot Coincident with Planetary Movements.
Smallest Spot to be Visible must Cover an Area of Fifty Thousand Miles.
Mr. Clements on *The Solution of the Sun-Spot Mystery in* 1900.
A Forecast of the Spots in 1901.
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SUN-SPOTS AND INDIAN RAINFALL

Continuous Sun-Spots, Maximaand Minima Curve, 1833 *to* 1905, *with Indian Famine Records and London Rainfall.*
No Invariable, not even Approximate, Correlation between Sun-Spots and Famines.
London Rainfall Shows no Relation whatever between Maximum and Minimum Number of Spots.
Significant Comparison between Number of Spots and Inches of Rainfall.
Sir Norman Lockyer's 'Pulses of Rain' Tested by Records.
Sun-Spot Phases Do Not Fall in 11-Year Cycles.
Periodicity may Vary from Seven to Sixteen Years.
Changes of Earth Air-pressure Not Dependent upon Changes of Temperature in the Sun.

THE RATIONALE OF INDIAN DROUGHTS

'Can Indian Droughts be Predicted? I, unhesitatingly, say, Yes.'
Diagram Representing the Moon's Phases and Circles during One Hundred and Eighty-six Years.
The Bearing of these Phases and Cycles on Indian Famines.
Position of Moon and Sun over India during the 1900 Famine.
Diagram Exhibiting Moon's Angular 'Pull.'

THE NEW METHOD OF LOCATING AND EXPLAINING SUN-SPOTS

Eight Full-page Diagrams with Explanations.
Prediction of Sun-Spots in 1901.
Six Spots in 1899 Analysed, their Position and Causation

Indicated by a Series of Full-page Diagrams of an altogether Unique Character.
Sun-Spots undoubtedly Caused by Planetary Attraction.

I. THE SOLUTION OF THE MYSTERY OF THEIR APPEARANCE

PROBABLY the first time that any English astronomer supposed a relation to exist between sun-spot phenomena and atmospheric conditions on the earth, as evidenced by observations made in equatorial regions, was in 1858. At that time the late Norman R. Pogson, C.I.E., for many years Indian Government Astronomer at Madras, and Meteorologist for the Presidency of Madras, was assistant to the late Manuel J. Johnson, Radcliffe Observer at Oxford, and President of the Royal Astronomical Society. The discovery of the variability in light (and doubtless also in heat) of certain stars led Mr. Pogson to the conclusion that the sun was a variable star, and 'all our meteorological phenomena, especially temperature and rainfall, must be influenced by its changes.' [1] He foresaw, as he says, vast difficulties in the way of arriving at any satisfactory proof of such conclusion, for, as he then argued, the effects must be compensating in different parts of the world, and any demonstration of such connexion must be based upon polar or equatorial meteorological records, and not upon those made in middle latitudes. 'My views,' he proceeded, 'were completely confirmed by the subsequent failure of several eminent meteorologists, who had naturally jumped at the same surmise, but, overlooking my precautions as to locality, had tried to deduce conclusions from comparing solar phenomena with European meteorological records. The failure was distinctly foreseen to my mind.' [1]

[1] East India (Report of Famine Commission) Appendix i. Miscellaneous Papers (Blue Book published in 1881), p. 32.

Fortune so far favoured Mr. Pogson as to give him, in an equatorial region, an opportunity to put his theories to the test. He was appointed Government Astronomer at Madras. To the duties of Astronomer were added those of Meteorologist, to the intense annoyance of Mr. Pogson, who, before all things, was an enthusiastic student of stellar phenomena and passionately devoted to observation of stars and planets. His work as an astronomer, especially his observations of Mars, greatly suffered because of his 'cloudy occupation,' as he now and then termed his meteorological work. His services as a meteorologist, in the opinion of the present writer, are a poor compensation for the loss of his almost unrivalled power as a stellar observer. There were scores of men in India who could have admirably done his meteorological work; there was not one who could have approached him in astronomical work. Notwithstanding that he felt it to be a degradation of his powers he performed his daily task as a meteorologist with great thoroughness; his meteorological records, published by his successor,[1] are a marvel of clear and accurate arrangement. The terrible famine in Madras, which extended from 1876 to 1878, afforded Mr. Pogson an opportunity to put forward the conclusions to which nearly twenty years of meteorological work in the part of the world which he considered best fitted for such observation, had brought him. He prepared valuable evidence, which he submitted to the Famine Commission of 1878–9. Accompanying tables gave form to the facts collected; indeed he traced an 'intimate connexion between sun-spot frequency, rainfall, and grain prices in Madras.'[2] He went on, however, to remark, referring to certain curves of maxima and minima:

[1] Professor C. Michie Smith, B.Sc., F.R.A.S., of whose research-labours too little is heard in the United Kingdom.

[2] Indian Famine Blue Book, 1881, p. 33.

'It will be at once seen on inspection that, although the successive maxima and minima of sun-spots and rainfall are not strictly correspondent as regards time, sometimes the one and sometimes the other taking priority, the *succession is perfect and unbroken so far throughout this century.* Intermediate rising and falling of the rain-curve is sometimes observable while the frequency of the sun-spots is diminishing, especially about the years 1849–52 and 1861–63; but a glance at the solar curve shows that it is itself subject to slight arrest and fluctuations during its descent; and that the rain-curve, in its very deviations from apparent order and regularity, is but obeying the solar impulses, and that too in so marked a manner as to render these sympathetic intermediate bends almost as striking a verification of the physical connexion between the two phenomena as the unbroken succession of the maxima and minima themselves.'

Finally, Mr. Pogson concluded that 'absence of spots means greatest solar energy and their prevalence a diminution thereof.' [1]

In thus 'maintaining' (to use his own word) this particular view, he came into conflict with other holders of the sun-spot theory, chief among whom is Sir Norman Lockyer, F.R.S. Sir Norman's mature contention, expressed in June 1902,[2] was: 'We know now that the spots at maximum are already full of highly heated vapours produced by the prominences, which are most numerous when the solar atmosphere is most disturbed.' In 1877, Sir (then Mr.) Norman Lockyer, by himself, and in association with the late Sir W. W. Hunter, K.C.S.I., Director-General of Statistics to the Government of India, and Mr. E. Douglas Archibald, B.A., F.R.M.S., then Professor of Mathematics in the Patna College, Bengal, stoutly asserted a connexion between sun-spots and rainfall. In 1902 Sir Norman is more strongly than ever of the opinion he expressed twenty-five years before. 'I

[1] *Ibid.*

[2] *Westminster Gazette*, June 15, interview by one of its staff reported in that journal.

believe,' he remarks, 'that within a few years it will be possible, by a scientific examination of the sun's disc, accurately to forecast a period of abnormal rainfall, and *vice versa* a period of abnormal drought.' [1]

In the controversy which arose in 1877, the present head of the Meteorological Council, Lieut.-Gen. Sir Richard Strachey, G.C.S.I., F.R.S., the President of the Indian Famine Commission of 1878–80, took part. He delivered a lecture before the Royal Institution of Great Britain in May 1877, on the physical causes of Indian famines, in which he thus dealt with the sun-spot theories affecting Indian rainfall:

'An opinion has, indeed, been quite recently published by Dr. Hunter, to the effect that the rainfall registers at Madras, which extend over sixty-four years, supply evidence of a connexion between the quantity of rain and the sun-spot cycles of eleven years or thereabouts. This idea is not novel, having been advanced some years ago by Mr. Meldrum and others, on the alleged basis of facts collected from many different parts of the globe.

'So far as Dr. Hunter's views are concerned, I have no hesitation in stating my own conviction, that the facts on which he relies do not support his conclusions. He has inferred, from what must be held to be altogether insufficient numerical data, that sure indications of periodicity exist. He arrives, by an arithmetical process, at certain figures, which he regards as the probable mean amount of rainfall in the successive years of the eleven-year cycle, and finding a maximum and minimum among them he infers that this is a proof of a true periodical variation. But such a result alone proves nothing. To test its value it is necessary to compare the calculated quantities of rain for the several years with the quantities actually observed, and then to consider whether the differences are of a character to justify the belief that the calculated quantities afford a reliable approximation to the truth, and what sort of approximation. Dr. Hunter does not seem to have been aware of the necessity for exercising this caution, though the extreme variation of

[1] Indian Famine Blue Book, 1881, p. 33.

the rainfall from year to year, to which reference has already been made, would appear to have been likely to suggest it. The only conclusion that seems possible, from such an examination of the figures as I have described, is the negative one, that they cannot be accepted as supplying any evidence in support of the views put forward by Dr. Hunter.

'Though this argument is mainly negative, and goes rather to discredit the alleged proof of Dr. Hunter's conclusion than the conclusion itself, yet much doubt appears to me to be thrown on the probability of any such direct connexion between the rainfall at Madras and the sun-spot period as has been spoken of, by a comparison of the Madras observations with those made during the same period at Calcutta and Bombay. It is extremely difficult to conceive that if such a connexion existed at Madras, it should not be apparent at the other two places, yet the same treatment applied to the Calcutta and Bombay figures as that adopted for Madras shows no correspondence in the results. Neither can any persistent relation be seen to exist between the quantities of rainfall at the three places. There is an occasional likeness at one time between one pair, at another between a second, and again between the third, but no uniformity. And this is what might have been expected, from what we know of the general manner in which precipitations of rain take place, and the oscillations of wet and dry weather occur.'

Some light is thrown on this controversy by the biographer of Sir William (then Dr.) Hunter in *The Life of Sir W. W. Hunter.*[1] Sir William visited Madras in January 1877, in connexion with the *Gazetteer* of Madras, which he was editing. He took the opportunity to visit Mr. Pogson, the astronomer; of his visit he remarks:—'I was all night long at the Madras Observatory, gazing at the stars and discussing sun-spots with Pogson, the Government Astronomer.' The fruit of that discussion was a collaboration with Mr. (now Sir) Norman Lockyer and the production of more than one joint article, and

[1] *Life of Sir William Wilson Hunter, K.C.S.I., M.A., LL.D., etc.*, by Francis Henry Skrine, F.S.S., late H. M. Indian Civil Service. Longmans, Green and Co., 1901.

at least one debate at the Royal Institution, where Sir Richard Strachey was confronted by Professor Balfour Stewart, who espoused the sun-spot theory, Sir Clement Markham, and others. It is alleged that 'General Strachey, in reply, admitted that the meteorologists were against him,' [1] a singular phrase to be used by a man who is now, and has been for some time, at the head of British official meteorological operations.

Associating himself with Mr. Clements in his detailed examination of sun-spots, their causation, and effect, the present writer is compelled to assert that Sir Norman Lockyer's theories appear to be emphatically of faith and not of works. For thirty years [2] solar phenomena have been Sir Norman's special study; upon them he has concentrated his great ability, while he has had the advantage of State provision to enable him to devote his whole time to his studies. Yet, though there have been eleven famines and scarcities in India (partly due to drought) since 1880, the solar observer, so far as is known to this writer, has not been able to forecast a single year's rainfall. Nor—it may be added, if with some confidence yet not dogmatically—will he, on such a basis, ever be able

[1] *Ibid.* p. 269. A friendly biographer claims too much for his hero when he says (p. 261): 'These communings with the heavenly bodies produced a theory which proved a nine days' wonder throughout the world of science.' Considering that Dr. Hunter's host, from whose conversation he, for the first time, apparently, gained his information, had broached this same theory at Oxford nineteen years previously, the claim of 'production' of the theory is untenable. Dr. Hunter himself, however, justifies his biographer in some measure, for, in his Diary of May 16, 1877, he says: 'The papers are nearly all devoting articles to my "Cycle of Rainfall and Famine"' (p. 269).

[2] In 1872, one of the writers of the pamphlet (Evidence submitted by Sir Norman Lockyer and others as above described) 'published a paper entitled *The Meteorology of Nature*, in which was developed the idea of a connexion between sun-spots and rainfall.' I think I am right in identifying Sir Norman as the writer referred to in the remark 'one of the writers.'

to realize the 'belief' recorded on p. 186, *ante*. The reason for his inability lies in the fact that the knowledge he seeks is not to be found where he believes it to be. On the other hand, Mr. Clements, the moment he turned his attention to India, was prepared to predict, and, having done so, has had the satisfaction to find his prediction prove correct. On my request, in May last, he examined the signs in the heavens and peered closely into past records, with the result that he announced there would, on the whole, be a good south-west monsoon. There might be apparent failure for a time, but, when the monsoon period was at an end, it would be found that so far as rainfall was concerned, there was little of which to complain. In the face of adverse appearances, so adverse as to cast India's administrators into a state almost of despair, Mr. Clements maintained his serenity, and was fully justified in so doing. To return, however, to the main argument of the text, Sir Norman Lockyer, and many other astronomers, because of loose statements founded on still looser observations of the moon's influence upon the earth and its atmosphere and concerning the moon and causation of weather, would seem to have become the victims of a fixed idea. That idea is to credit the sun with the parentage of all atmospheric phenomena and to deny to the moon any controlling action over aught earthly save ocean tides and earth tremors. There is no escaping the palpable evidence of the tides and the tremblings. It is true the human eye cannot discern the agitation of the airy envelope in which we live and move and have our being, but the instructed imagination of every one, especially of those whose sole foundation of observation is a belief in the law of gravitation, should conceive the possibility of the 'pull,' which lifts the waters and draws earthly particles upwards, being able also to control and influence (to an even greater extent) the more easily affected

atmosphere. That this evident probability, one might even say certainty, is overlooked, or ignored as of little importance, by men of scientific renown is a psychological puzzle in mental aloofness. In 1878, Sir Norman Lockyer and his coadjutors (Dr. Hunter and Mr. Archibald) thus committed themselves to the solar energy as the prime cause of everything terrestrial:

> 'It was, perhaps, scarcely necessary thus to clear the ground for the general statement, now an accepted fact of science, that, with the exception of tide-work all our terrestrial energies come from the sun : : : the solar energy is the great prime mover of all the changeable phenomena with which we are here familiar, especially in the inorganic world.'[1]

With the door of his mind so securely closed, barred, and bolted, as this dogma indicates, and with a continually dominating *arrière pensée* that the sun was the author 'of ALL the changeable phenomena with which we are here familiar,' an attitude which, surely, is the very negation of the scientific mind, there is no wonder that, after a generation of inquiry, Sir Norman Lockyer finds (though he does not admit the finding) that drought prediction for India (and elsewhere) is a will-o'-the-wisp. Apparently the true story of the earth's atmospheric changes will not be told by an examination of the number and grouping of solar prominences, be this occupation never so accurately carried out. But that, unhappily, does not prevent the continual advocacy of the sun-spot cycle theory. Mr. Archibald, within recent years, has carried on his ancient searching for that which existeth not. His object was to establish a connexion between the 11-year period of maximum and minimum number

[1] Evidence concerning the Cycle of Sun-spots and of Rainfall in Southern India, contributed to the Famine Commission of 1878–80, p. 20, Appendix i. *Famine Series of Blue Books.*

of sun-spots and the occurrence of famine in India. He failed in his purpose. He was bound to fail, as will be seen from the following record, giving the scarcities and famines which have occurred in India since 1854, and which is partially compiled from the report of the Famine Commission of 1897–98:

Years:	Intervals:
1857–58 . .	3 years from previous scarcity or famine.
1860–61 . .	3 ,, ,, ,, ,, ,, ,,
1868–69 . .	7 ,, ,, ,, ,, ,, ,,
1873–74 . .	4 ,, ,, ,, ,, ,, ,,
1876–77 . .	2 ,, ,, ,, ,, ,, ,,
1884–85 . .	7 ,, ,, ,, ,, ,, ,,
1889 . .	5 ,, ,, ,, ,, ,, ,,
1892–93 . .	3 ,, ,, ,, ,, ,, ,,
1897–98 . .	4 ,, ,, ,, ,, ,, ,,
1899–00 . .	2 ,, ,, ,, ,, ,, ,,
1900–01 . .	1 ,, ,, ,, ,, ,, ,,

This record shows—

two intervals	of	7	years each,
one interval	,,	5	,,
two intervals	,,	4	,,
three ,,	,,	3	,,
two ,,	,,	2	,,
one interval	,,	1	,,

Some so-called 'minor scarcities' are omitted in the above tabulation.

Though they place little account in the sun-spot theory, the meteorologists in the United States are sun-worshippers equally with Sir Norman Lockyer himself. Professor Garriott, 'Forecaster-in-Chief' to the Government, in discussing the question, 'Is it the Sun that is Making all the Trouble with our Weather?' declares, 'The sun is the cause.' 'And why not?' he asks; he answers his own question in a manner most satisfactory to himself. I am so anxious that the views I challenge and, I believe, disprove, should be stated by

their most strenuous advocate, that I give here Professor Garriott's observations in full.[1] He says:

'Some cause there must be for such extraordinary weather. Everybody is asking why? It is a most interesting and even fascinating question. But we must approach it with due respect and even with some degree of hesitation, inasmuch as the problem involved is so formidable.

'One thing we may reasonably take for granted, and that is that the cause of such an extraordinary season lies not close at hand. It is not to be found inside of the earth, or on the surface of the earth, or in the atmosphere that surrounds the earth. It is somewhere outside of our planet and far beyond the tenuous envelope of air which embraces it.

'It cannot be the moon, though weather-wise persons in olden times were disposed to credit that innocent orb with many things for which it was not in the least responsible. The planets, then? No; they are too far away. Obviously there remains only one conclusion—namely, that the sun is the cause.

'And why not? It does not require any stretch of the imagination to suppose that the sun may influence the weather on the earth. Is not that fiery ball a source of all our light and heat and power? It would be surprising, indeed, if the sun did not possess very great influence of the kind.

'It is natural, therefore, to look to the sun as a likely cause of such remarkable and exceptional meteorological phenomena as have been observed recently. We have had unusual cold and many peculiar storms following unusual tracks. But it is not only we in the United States who have noticed and experienced these strange conditions; in Europe also a similar state of affairs has ruled. In fact, so well as we can make out, the summer has been chilly and stormy over most of the northern hemisphere.

'If the sun is accountable, how and in what way does it exert so tremendous an influence over our climate—over the climate of an entire hemisphere of the earth? Nobody can say with certainty, but the likelihood seems to be that this control is exercised through an electrical medium. We have had a summer of cold and rain (if this theory be correct)

[1] *The New York American and Journal*, Sunday Edition, August 17, 1902.

owing to a disarrangement of the ordinary atmospheric pressures by the electro-magnetic power of the sun's radiant energy.

'The sun is a gigantic spherical magnet. It acts as a magnet upon the earth, emitting electro-magnetic force. Its magnetic influence extends out into space, embracing the earth and the other planets. And, with the variations of electrical energy due to the changes that are constantly going on in its flaming surface, there are changes in the weather on the earth.

'This is by no means to say that all weather changes on the earth are attributable to the sun, but merely that the solar orb does seem in a general way very powerfully to influence climatic conditions. There seems to be no doubt of the fact that hurricanes and other violent meteorological phenomena on the earth coincide to a marked extent with fiery outbursts on the sun. On the other hand, when normal conditions on the sun are least disturbed, the weather on the earth is most equable.

'To sum up, the sun's magnetic influence, stretching out and embracing the earth, varies the earth's magnetism and gives rise to weather-changes. Accordingly, weather-changes correspond with variations of solar energy, such as are marked by outbursts on the sun's surface, which are easily observable with a telescope.

'If this idea be correct, the sun assumes a new interest from our point of view. An immense electro-magnet hanging in the sky, it not only furnishes us with light and heat, but governs to a great extent the weather which has so marked an influence upon all of our daily doings and upon our very thoughts and feelings.'

The case for the sun is stated with much ability and some plausibility. Indeed, no heavenly body ever had such strenuous and whole-hearted worshippers. Their belief is like the Hebrew magician's rod which, in the presence of a King of Egypt, swallowed the other rods turned into serpents. Solar worship seems to exclude even the idea of any other object deserving of a single thought, to say nothing of adoration. But, in view of the verified facts in these pages, which relegate the sun to a very subordinate place in Nature's weather-making

bureau, foundations of belief are found to be merely speculations possessing no convincing force. Certainly the least convincing statement is that which declares, 'It cannot be the moon' that has caused 'the trouble with our weather.' As a matter of fact, the troubler of the meteorological Israel has been the moon, backed in all its doings to the utmost of its power by the sun.

The mystery of sun-spots is not an inexplicable mystery. In the unravelling of the tangled skein with which some succeeding pages are occupied the phraseology employed and the research exhibited are almost entirely the work of Mr. Clements, while the diagrams are all his. To him, and to him alone so far as I know, belongs the credit of making these (hitherto) rough places plain.

In the realm of Nature, at present, there is no more interesting phenomenon than that of sun-spots, and there is no problem that more urgently awaits solution. Scientific ingenuity has been baffled. The meteor-theory will probably never get beyond the range of suspicion, and the suggestion that there are self-generated pulses of activity causing sun-spots, we cannot, with our present knowledge, hope to prove. With regard, however, to the planetary theory we have something tangible, and we ought to be able to decide whether the planets are the cause of sun-spots or not. The reasons given in existing works on astronomy against the planetary theory are not convincing. Although De la Rue found that when two powerful planets were in line, as seen from the sun, the spotted area was much increased, he did not persevere with the line of inquiry thus indicated and solve the question by an accumulation of data; this was, doubtless, due to want of knowledge of the *modus operandi* of the planets in producing spots. He particularly observed the effects of Mercury and Venus, Mercury and Jupiter, and Venus and Jupiter, but why he and others should have

omitted the earth as a factor in the production of sun-spots is not easily to be understood.

We find a similar grouping of the planets in 1856, 1867, and 1878, to that which attracted De la Rue's observation, when there was a minimum of sun-spots. The earth was at an angle of about 150° in longitude from Venus, Jupiter, and Mars respectively; taking the zenith or nadir positions, Mercury, Venus, Earth, Mars, Jupiter, and Saturn were located round the sun in a compass of about a quadrant at varying intervals above and less than 15°; consequently any two of these planets were very rarely in line so as to produce a combined effect at more than two points, one north and the other south of the solar equator. In 1843 and 1888, years also of minimum spots, Venus was on the opposite side of the sun from the earth, but not in line or even nearly so; no combined effect was therefore produced affecting more than two points. In fact during years of minimum spots the planets are grouped so that only a minimum of spots is produced, and the spots are generally confined to a fourth part of the sun's surface.

If we take the grouping of the planets at a time of maximum sun-spots, we find that they are usually on the same side of the sun as the earth. When they are not on one and the same side they are placed in line exactly opposite to act in unison with another planet; or, not being in line, they are so situated on the other side of the sun as to produce their tide-raising power within an angle of 90° from the earth or other powerful planet, and the spots are produced on the sun's face next to us. There was a peculiar combination in 1848, when Mercury and Mars were in conjunction on December 20, producing a nadir tide at less than 90° from Jupiter, while Venus was producing another tide with the earth at an angle also just under 90°. And not only so, but there was an interaction and combined action also at an angle of 45° among

these six planets, including Saturn ; great sun-spot frequency was the consequence.

In cases of maximum spots the planets, taking their zenith and nadir positions relative to the earth, occupy a longitudinal extension from 90° to 135°. At times of maximum spots two or more planets are close together in longitudinal position, causing a combined cumulative effect, whereas at times of minimum spots the planets are widened out so that the combined effects at angles of 45° occur only at two points instead of at many. For instance, during July 1868, Mars, Earth, and Venus were acting together as one body, latitudinally and longitudinally, causing a maximum of spots, the Jovian nadir-tide being close by. During January 1881 Mercury, Earth, Mars, and Jupiter were alineated, producing a great sun-spot combination. During August 1893 the Earth and Mercury were alineated, producing a combined effect with Jupiter at just under 90°, the nadir-tide of Venus lying between the nadir-tide of Mars, intensifying that of the Earth. The great sun-spot frequency during August 1870 was mainly due to the alineation of Venus, Jupiter, and Mars ; and during May 1870 the greatest sun-spot frequency of modern times occurred when Jupiter and Mars on the other side of the sun were alineated with the Earth, and Mercury respectively with Venus, at less than 90° distant from the heliocentric longitude of the Earth, Mercury, and Saturn. All six planets were so grouped by alineation and otherwise as to produce their greatest effect.

With the force of gravity at the solar surface twenty-seven and a half times as great as that of the earth, it follows that the direct upward 'pull' of the planets, singly or combined, would be nothing, and that it would increase up to 45° all round, where the planetary tidal effect would be at a maximum, as the 'pull' would be mostly at right angles to the sun's gravity, and therefore unopposed by it.

I hope, (remarks Mr. Clements,) I have here demonstrated that minimum and maximum sun-spots are produced by the planets acting and interacting with each other at an angle of 45°.

As the positions of the planets with reference to the sun are known and can be calculated for any number of years in advance, it will be possible to predict the occurrence of minimum and maximum spots and to definitely localise them upon the solar surface. On Christmas Day 1900, Venus, Mercury, Jupiter, and Saturn were on the other side of the sun, and were so isolated that only comparatively few and small spots could be produced. During the whole of January 1901 the same four planets were on the other side of the sun from the earth, which gradually approached Mars to within 12° by the end of the month. There was a minimum of spots during that month, but there were more on the 9th, 14th, and 21st, due to the alineation of Mercury with Jupiter, Saturn, and the Earth respectively. At the beginning of the year 1904 I find Venus in line with Mars, and rapidly approaching alineation with Jupiter, so that a large area of spots will be produced, particularly with Mercury rapidly approaching the Earth, which will be within 90° of Venus, forming spots at 45° angular distance from each planet.

At the commencement of 1905, moreover, a maximum of sun-spots will be produced, all the nearest six planets excepting Saturn being on the Earth side of the sun, the Earth being alineated with Mercury and Venus with Jupiter, the alineation occurring at an angle less than the quadrant.

II. THE NON-RELATION OF SUN-SPOTS TO RAINFALL, AND THEIR NON-CONNEXION WITH INDIAN DROUGHTS

'It is very difficult to conceive in what manner the planets, so small and so remote, can possibly produce such profound and extensive disturbances on the sun.' So writes Professor Young on page 150 of his work on astronomy, and on the following page, he says: 'No planet-lifted tides can directly account for sun-spots.' This seems to be the opinion of astronomers, but no astronomer has heretofore exactly explained how sun-spots are produced.

However, there is a general suspicion that the planets are in some mysterious way concerned in the production of sun-spots. Let us see if any light can be thrown upon the subject. In Fig. 47, P represents a planet, and S the

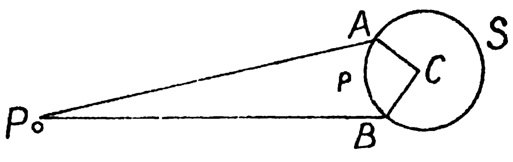

FIG. 47.

sun. It is self-evident that the planet P cannot pull out the photosphere at the point P against the sun's gravity, but at points A and B and all round in a circle at an angle of 45° most of the force of the planets is exerted in pulling at right angles to C A the direction of solar gravity, and is therefore unopposed by it. Thus, at an angle of 45°, the tide-raising power of a planet is almost wholly effective in lifting the photosphere, as there is no gravity to oppose it. Even Uranus and Neptune would have some tide-lifting

power on the sun's photosphere, but it would be so small compared with the other six nearer planets that they may be omitted from consideration.

The planets Mercury, Venus, Earth, Mars, Jupiter, and Saturn would each have at an angle of about 45° considerable tide-lifting power, and the effect would be very much greater when two or more of them acted together at the maximum tide-lifting angle. In Fig. 48 let B be a planet overtaking A, a planet further from the sun. When B has arrived within 90° from A the tide-producing circles at angular distance of 45° will touch at *a*, where a large spot will be produced. And as B over-

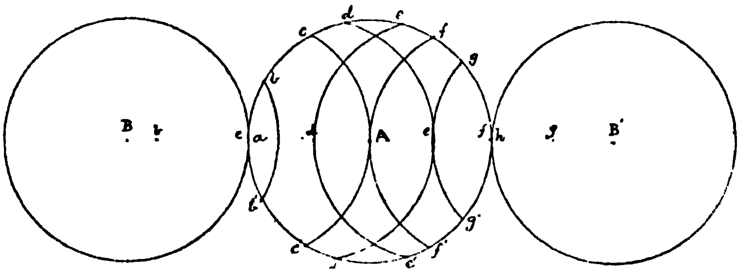

FIG. 48.

takes the planet A the circles will cut at *b c d* to the north of the solar equator and *b′ c′ d′* to the south, and at these points large spots will be formed, and when B gets in a line with A and the sun's centre, spots will be formed all round a circle on the sun's photosphere. B will immediately pass A to the right, and the circles will cut successively at *e f g* and *c′ f′ g′*, where spots will be formed, and eventually the planet B will get 90° to the right of the planet A, and the spot at *h* will be found to be immediately broken up when the angular distance is still further increased.

In the case of Fig. 48, where the planets moved directly over the sun's equator, spots would be formed from the equator at A all round by *b c d* and *e f g*, down to the

equator again, extending, when the planets were in line, to 45° from the sun's equator.

As a rule the planets do not pass each other in this way, but a little to the north or south of each other, as in Fig. 49, the result being that in the northern hemisphere the spots are formed along the A curve X, and to the south of the equator the spots are formed along the B curve Y. In this case the further north or south spots are less than 45° from the sun's equator. And from Fig. 49 it will be observed that as spots are formed going up, in the direction of the arrow *c*, and then in the same latitude going down the curve, in the direction of the arrow *d*,

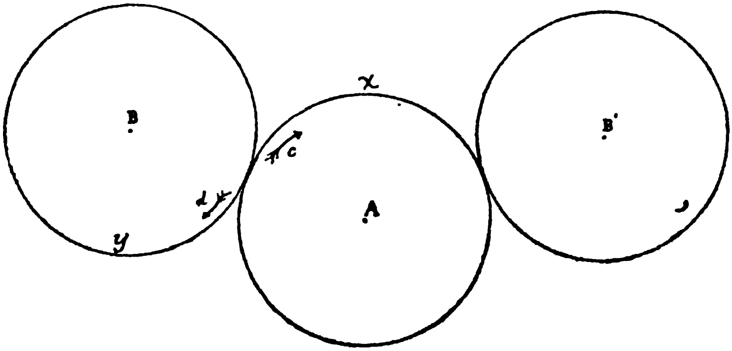

FIG. 49.

it is readily explained why there should be a predominance of sun-spots between 10° and 22° north and south of the sun's equator.

In Fig. 48, if the planet A were stationary while the planet B passed it, the series of sun-spots would form a circle, but as it is moving forward in the same direction, only more slowly, semi-ellipses are formed north and south of the equator. In June and December the spots appear to move in straight but oblique lines on account of the tilt of the sun's equator with the ecliptic at those times.

The drifting of one spot relatively towards another is explained by the fact that Mercury will overtake any

other planet quicker than Venus, and Venus sooner than the Earth, and so on; thus, with a quick-moving planet, spots move more rapidly and overtake those formed by slower-moving planets.

Spots have a whirlpool motion as if caused by a hurricane, and frequently different members of the same group of spots, and even portions of the same spot, revolve oppositely. This rotatory movement of sun-spots is similar to earthly storms caused by the tidal lines of the moon and sun crossing at an angle of 45° at the earth's surface.

The repeated crossing and recrossing of the tidal lines of the planets moving at different speeds account for the rapid changes in spots and for spots of every imaginable variety and degree of rapidity, with their occasional instantaneous disappearance.

Usually a spot does not last more than two or three months; it takes Mercury two months to get out of the influence of the Earth, and nearly a fortnight longer to get out of that of Venus. It takes Venus about nine months to get beyond the Earth's influence, and it is about a year before the Earth can get out of the reach of Mars, while Jupiter keeps within the Earth's influence for nearly ten years. This explains why some spots have been observed for fifteen months. Mars and Jupiter can produce a spot lasting for that length of time.

The least spot visible in a powerful telescope must have an area of 50,000 square miles (about the area of England); in 1858 one spot was observed 143,500 miles broad. In 1873 the relative number of spots was 140, but in January 1879 there were only three visible, which, in all probability, meant that there were a large number under 50,000 square miles, and, therefore, invisible. September 1, 1859, was a day of great spots, and from August 28 to September 4 the earth was convulsed with magnetic disturbances. On August 28, 1859, Venus, Mars, and

Saturn were together, and nearly alineated with the Earth and Mercury together, the combined spots of the 28th being suddenly separated on the 1st, moving about 35,000 miles in five minutes.

It would seem, from research already made, every phase of sun-spots, from the earliest records, can be explained by planetary action.

The manner in which sun-spots are formed may now be more fully illustrated. In Fig. 50 let V representing Venus overtaking Earth, E, the tide-lifting curve of E, at an angle of 45°, touching that of E at the point *a*,

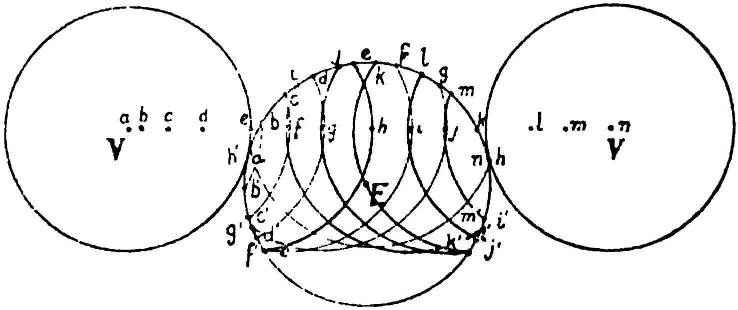

FIG. 50.

forming a spot which will be continued along the curve of E to *b*, *c*, *d*, *e*, *f*, *g*, *h*, *i*, *j*, *k*, *l*, and *m*, finally leaving the tidal circle of A at the point *n*, when the spot would break up.

Of course it would be easy to follow the spot from *a* to *i*, for its motion would be continuous, but the spot at *i* suddenly jumps to *j*, the position previously occupied at *d*, and from these it goes to *k*, *l*, *m*, finally disappearing at *n*, when the planet V has passed E by more than 90° to the right. To the south of the sun's equator the spots are arranged altogether differently, being crowded together at *b′*, *c′*, *d′*, *e′*, *f′*, *g′*, *h′*, the spots *j*, *k*, *l′*, *m′* being thrown together on the opposite part of A's tide-lifting curve, but in the same latitude. By Fig. 50 all the different phases

of sun-spots can be explained—the continuous movement, the sudden break-up of the spot at *i* and the immediate formation of another spot at *j*—the grouping of spots from *c′* to *g′* and *j* to *m* south of the equator, and the continuous elliptical movement from *a* to *i* north of the equator, as well as the formation of so few spots at the equator and

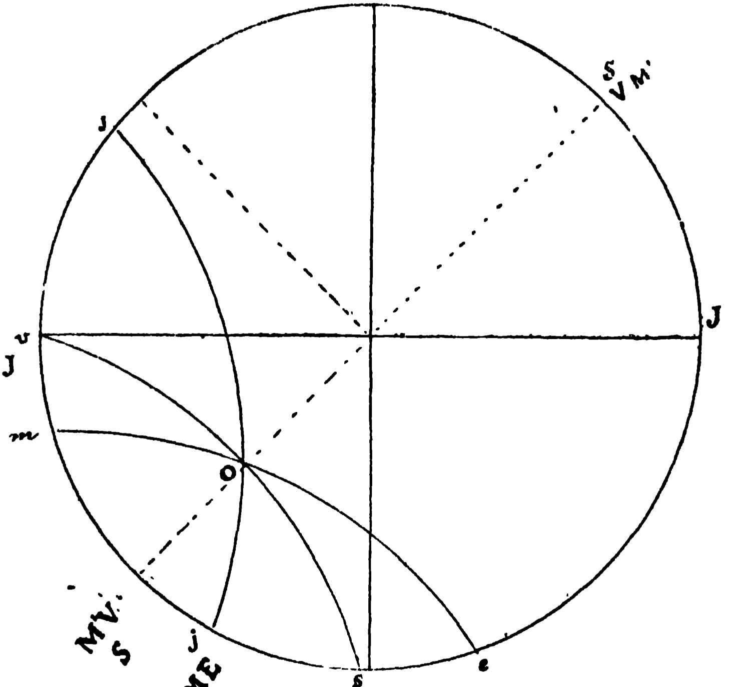

FIG. 51.

at 45° from the equator, the great bulk of spots being formed from 10° to 22° north or south of the equator.

In my paper on *The Solution of the Sun-Spot Mystery*, which was published on December 25, 1900, Mr. Clements proceeds to remark, I attempted to demonstrate that sun-spot frequency was due to the particular grouping of the planets and their tide-lifting power, and in that paper I pointed out that there would be relatively

few spots during January 1901. I then attempted to give a summary of spot-formations for the remainder of the year 1901. My forecast was expressed in the following terms: 'During February Mars will be the only planet on our side of the sun, the other planets being so detached on the opposite side of the sun that few visible spots will be formed, and these will appear on the 4th and 5th, 13th and 22nd, Mars to Venus, acting first with Jupiter and then with Saturn, the Earth being alineated with Mars on the latter date. During March, Venus, Jupiter, and Saturn will be on the other side of the sun, and there will be more spot-area about the 7th, when Mercury and Mars will be alineated, and on the 9th, when Mercury and Earth will be in line, and also on the 20th, it will be interesting to observe how the new moon will increase the spots at a time when the Earth is acting with Jupiter at an angle of 90°. During April Venus is the only planet on other side of the sun, but the other planets are rather separated, except about the 1st, 7th, and 9th. During May Mercury and Venus will be on the opposite side of the sun but generally separated, except on the 1st and 21st, when Venus will be alineated with the Earth and Mercury respectively, more spot-area being caused thereby. During June Venus will be alone on the opposite side of the sun from the earth, greater effects from alineation being produced on the 6th, 12th, and 28th. During July Venus is still the only planet on the other side of the sun. It will be interesting to watch what increased effect the earth has when in line with Jupiter at the time of full moon. Round the 6th there is a powerful alineation of planets that ought to increase the spot-area. During August there will be a smaller spot-area than usual, but there will be a powerful combination at the time of full moon in September among four planets, and on the 4th Mars will be in line with Venus. During October there will be alineation on the

1st and 9th, and in November there will be alineation on the 1st, 6th, and 29th, and in December there will be alineations of the planets on 1st, 7th, 22nd, 28th, and 31st, Venus having since November been on the same side of the sun as the earth.

In order to explain the seven days of great sun-spot activity I have drawn Fig. 51, showing the planets in their

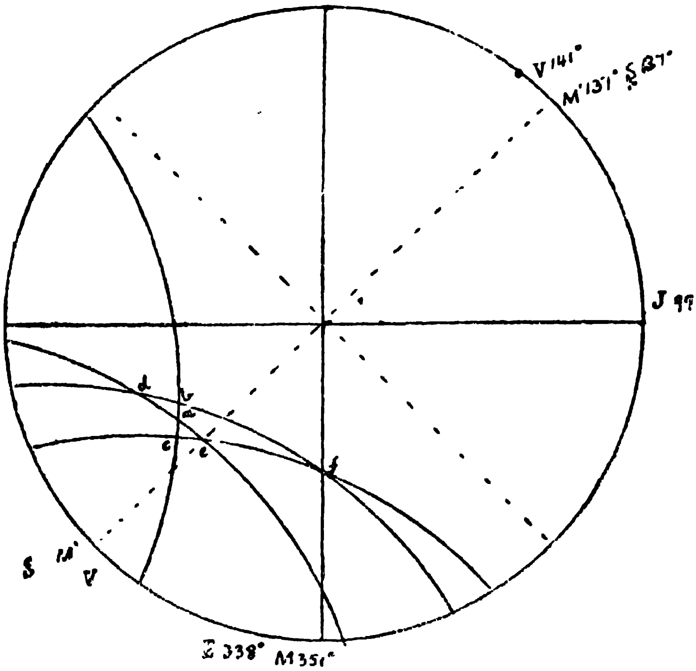

FIG. 52.

relative positions on August 28, 1859, the Earth and Mercury being together in longitude 334°. Venus, Mars, Saturn, and Jupiter being on the other side of the sun, Venus and Mars being alineated with Saturn close by, the relative nadir positions are given for Venus, Mars, Jupiter, and Saturn on the same side of the sun as the Earth. The combined tide of the Earth and Mercury would extend from *m* to *e*, and that of Venus, Mars, and

Saturn from *v* to *s*, and that of Jupiter from *j* to *j* along the sun's equator almost coincident with the ecliptics. In this case the tidal curves at an angle of 45° would cross, and a great sun-spot area would be formed at o. On September 1st following the great spot at o in Fig. 52, became split up into six separate spots, *a*, *b*, *c*, *d*, *e*, *f*, the *f* spot, due to the rapid motion of Mercury, which had gone half a quadrant in four days at the rate of 7,000 miles per minute over the photospheric surface, producing the greatest magnetic disturbance of modern times.

'During the middle of June 1900, there were several prominent spots sufficiently large to be seen by the naked eye. These spots were caused by the alineation of Venus and Jupiter not far from the Earth, which was in contiguity with Saturn.

'In considering the formation of a maximum or a minimum number of spots the whole of the planets have to be taken into account.'

SUN-SPOTS AND INDIAN RAINFALL

The continuous sun-spot curve which faces this page is calculated for the years 1841 to 1896. It has been drawn in accordance with the scale of sun-spot frequency given from figures obtained by Dr. Wolf, and the dotted part from 1833 to 1841, and from 1896 to 1901, I calculated from the tidal attraction of the planets Mercury, Venus, Earth, Mars, Jupiter, and Saturn upon the sun's photosphere productive of sun-spots.

The letter F is placed opposite those years during which famines occurred in India. There can be no connexion between years of maximum spots and famines, as only two famines, those of 1837 and 1860 happened at the time of the maximum phase, nor with the minimum phase as very few took place during the years of minimum spots.

Taking the central years of the ascending curve, there were famines in 1868, 1880, and 1890, but none during 1835, 1845, and 1858, showing that there is no connexion. These years are marked *c a c* on the curve. And taking those years central on the descending curve denoted by *c d c* there were famines during 1874, 1885, and 1896, but none in 1840, 1852, and 1863, thus proving the absence of any correlation between famines and the crossing of the known and the unknown lines of the spectra of the descending curve.

Therefore, whether we take the central years of the ascending or descending curve, or the time of maximum or minimum spots, there is no invariable correlation between sun-spots and famines, generally the result of a deficiency of rainfall.

It was all very well while sun-spots were a mystery to

imagine that there was some occult connexion between them and weather, but since their causation by planetary tidal action has been explained there is no excuse for any one affecting to believe the impossible. The tidal action of the moon upon the earth's atmosphere is so immensely greater than that of the planets that they may be omitted from consideration as factors in weather-production. Any excess or deficiency of heat that may be caused by the planets in the production of sun-spots must be imperceptibly small; but even if the excess or deficiency of sun-spot heat was a few degrees more or less it would have no appreciable effect upon our weather or rainfall, which is caused by lunar tidal action.

Comparing the rainfall of London with the sun-spot curve, we find that at six periods of maximum spots in 1837, 1848, 1860, 1870, 1883, and 1893 there were 19·44, 29·81, 32·24, 21·32, 21·76, and 20·11 inches of rain respectively, as marked opposite the year on the curve, there being two wet maximum years and four more or less dry ones. Again, take the years of minimum spots, 1843, 1856, 1867, 1878, 1889, and 1900, we find there were, as indicated on the curve, 25·85, 22·21, 26·29, 34·08, 23·16, and 22·23 inches respectively of rainfall, one wet, three of mean rainfall, and two dry, thereby showing no relation whatever between minimum spots and rainfall. Further, let us take the central years of the ascending curve, 1845, 1858, 1868, 1880, and 1890, with 19·77, 29·68, 23·40, 17·28, and 22·75 inches of rain respectively in the reverse order, as marked on the curve, we again find no relation between curve and rainfall, there being one wet, two mean, and two dry years.

Taking the central years of the descending curve, 1840, 1852, 1863, 1874, 1885, and 1896, with 19·46, 35·34, 21·59, 18·82, 24·01, and 22·42 inches of rain respectively falling at London during those years, we find no connexion between rainfall and curve.

The following table, giving the rainfall for the month of July for London for various years, shows that there is no connexion whatever between rainfall and spots, in the dry years there being nineteen spots for one inch of rain, and in the wet years only six spots.

Year.	Rain.	Spots.	Year.	Rain.	Spot
1879	1·13	8	1881	12·38	77
1883	2·27	81	1882	13·03	45
1887	2·53	23	1884	9·35	53
1888	3·67	3	1886	11·53	30
1891	1·56	58	1892	8·11	77
1894	3·54	106	1893	7·36	89
Total	14·57	279	Total . . .	61·76	371
Proportion . .	1	19	Proportion . .	1	6

The point being one of great importance, the theory of sun-spot causation of drought in India may be dealt with in another way. The table that follows gives data, which may be thus described:

Column.
1. Years of maximum sunspots,
2. ,, ,, minimum ,,
3. Eleven-year cycles from 1893,
4. ,, ,, ,, ,, 1889,
5. ,, ,, ,, ,, 1880,
6. ,, ,, ,, ,, 1885,
7. Central years of ascending curves,
8. ,, ,, ,, descending curves.

The letter F placed against a date denotes a famine year.

1.	2.	3.	4.	5.			
1893	1889	1893	1889	F 1880	F 1885	F 1880	F 1885
1883	F 1878	1882	F 1878	F 1869	F 1874	F 1868	F 1874
1870	1869	1871	1867	1858	1863	1858	1883
F 1860	1856	F 1860	1856	1847	1852	1845	1852
1848	1845	1819	1845	1826	1841		1846
F 1837	F 1833	F 1838	F 1834	F 1825	1830		
1829	1823	F 1827	1823	F 1814	1819		
1816	1810	1816	F 1812	F 1803	1808		
F 1804		1805	F 1803				

'In his paper, presented to the Royal Society in November 1900, Sir Norman Lockyer stated that there were two

pulses of rain, one near the maximum and the other near the minimum of sun-spots. Column 1 shows that there were no pulses of rain in 1860, 1837, and 1804, years of maximum spots, and column 2 shows that there were no pulses in 1878 and 1833, years of minimum spots. These columns (1 and 2) also prove that Indian famines do not always occur (as Sir Norman has stated) in the interval between maximum and minimum spots.

Columns 3 and 4 show that the maximum and minimum spots do not run in eleven-year cycles, so that famines could not be predicted from the spots with any certainty.

Columns 5 and 6 demonstrate that the famines which had occurred between 1811 and the beginning of the period covered by the inquiry all fell on, or nearly on, the same intervals, counting back eleven years, either from 1880 or 1885, the central years of the intervals between the pulses, as stated in the *North American Review*, is not a correct representation of the facts of the case.

What is the good of going back in cycles of eleven years when the sun-spot phases do not thus go? Column 1 shows differences of from eight to thirteen years between the times of maximum spots; in future there will be such differences, and even greater ones, so that famines predicted on the eleven-years cycle would be bound to be out of reckoning by several years even if famines did occur; but, when we recollect that phase after phase of sun-spots may pass, even for fifty years, without any serious famine in India the untrustworthiness of sun-spot observation as a guide to famine occurrence, becomes palpable.

In columns 7 and 8 the actual years of the ascending and descending curves are given, showing that out of nine years famines only occurred in four. According to Sir Norman's theory there ought to have been a famine during 1845, but there was none for six years previously

or nine years afterwards; further, 1858 was four years after a famine and two years before one.

It matters not in what aspect the speculations based on solar activity or inactivity in the matter of spots be regarded, they all break down on critical examination. Take one of the tables in which the year 1880 is adopted as the central year on the ascending curve of spots, and eleven years is assumed as the interval between corresponding sun-spot phases:

1880 − 11 = 1869, famine in N.W. Provinces (1868–69).
1869 − 11 = 1858, no famine.
1858 − 11 = 1847, no famine.
1847 − 11 = 1836, famine in Upper India (1837–38).

It may be repeated sun-spot phases do not follow at intervals of eleven years, but may vary from seven to sixteen years, so that so far as the prediction of famines is concerned no reliance can be placed upon them, and maxima and minima of spots may pass for many years without coinciding with any serious famine in India.

Sir Norman lays down a law that Indian famines occur between maximum and minimum spots, while, according to the table given above, famines occurred in 1837 and 1861, years of maximum spots. As famines did not take place during 1858, 1845, and 1834, the years really corresponding to 1880, it is clear that there is no correlation between the ascending curve of spots and famines. In fact famines do not run in eleven-year cycles or in any other order that is correlated with the incidence of sun-spots.

If the weather and famines, the latter coinciding with prolonged drought, were correlated with sun-spots, there would be an invariable sequence. However, take India or any other country, no invariable sequence as an effect of sun-spot phases is to be found. There is really no correlation, and to call several coincidences, occurring during a few years a law of nature, is unscientific, especi-

ally when a wider view clearly demonstrates a great preponderance of exceptions.

Sir Norman assumes, without any apparent proof, that the changes of temperature on the solar surface cause similar changes of temperature on the earth, and that these changes are the cause of changes of air-pressure that produce variation in the weather. This is not the case, for changes of air-pressure are chiefly produced by the moon as our great tide-raising power, and temperature is the outcome of pressure, the heat of the sun being cut off to a greater or less extent by pressure-produced clouds and the direction of the wind controlled by the moon.

THE RATIONALE OF INDIAN DROUGHTS

'If I were asked,' says Mr. Clements, 'Can Indian droughts be predicted, I should unhesitatingly say, Yes. And I will, if you please, attempt to demonstrate this from the accompanying figure, in which N denotes nodes

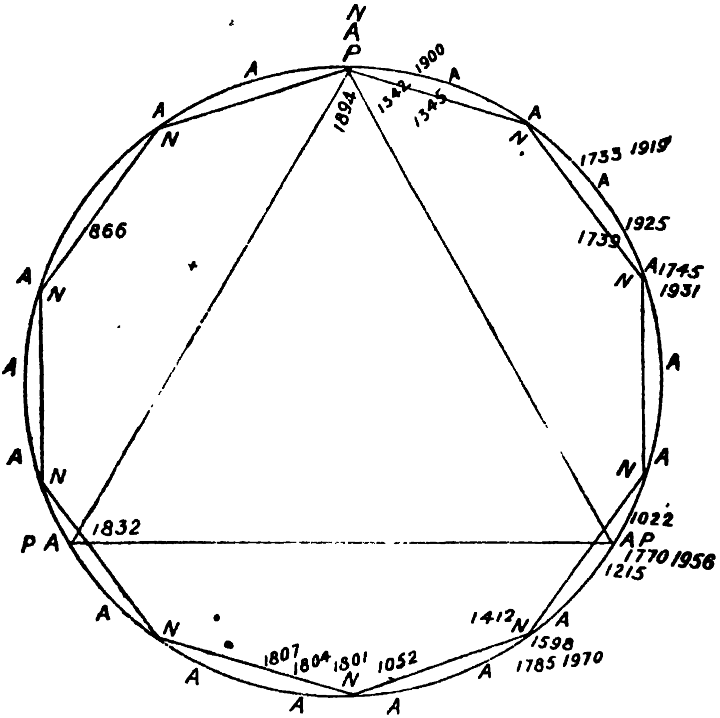

FIG. 54.

of 18·6 years, A apses of 8·86 years, and P the cycle of phases in 62 years. N A P at the top of the curve gives the starting-point July 3, 1894, when the nodes, apses, and phases were together. The whole curve represents a sweep of 186 years, during which time the phases

make three complete cycles; the nodes ten cycles, and the apses twenty-one revolutions. Six years to the right of the starting-point N A P at the top brings us to 1900 marked on the curve, and three complete sweeps backwards brings us to the year 1342, when a great famine commenced, and terminated in 1345, affecting 'the whole of India.'

Going backwards, the phases occur at the same time of the day every sixty-two years, but four or five days earlier in the month, and in three times sixty-two years the phases would occur thirteen or fourteen days earlier, and in three times 186 years, bringing us back to the year 1342, the phases would occur forty-one days earlier, but, as twelve days have to be deducted, it makes the phases of the moon occur at the same time of the month in 1900 as in 1342. Hence their action in producing drought and consequent famine in India would be similar.

There was no famine in 1714, just 186 years before 1900 or during 1528, two periods of 186 years each backwards, because, allowing twelve days for those dropped out of September in 1752, there would be such a difference that the times of the phases in 1528 and 1714 would not sufficiently correspond so as to act similarly in producing drought.

During the famine of 1900 the moon was at or near the ecliptic, and so was acting conjointly with the sun, just over the centre of India; consequently the atmosphere there would be practically unaffected, for their attraction would be neutralized by that of the earth's gravity, about nine million times as great. The combined attraction of the moon and sun over India would gradually increase from, say, Allahabad as a centre, to 45° all round, where the attraction would be at a maximum, with great air disturbance and rainfall.

In this way the air over India would be comparatively still, and there would be little, if any, rain.

In Fig. 55, let E represent the earth, and I India, with the moon M overhead. At I India the moon cannot pull up or disturb the air, because the force of gravity is many million times greater, but at A, 45° from I, gravity has little effect, because the moon pulls more

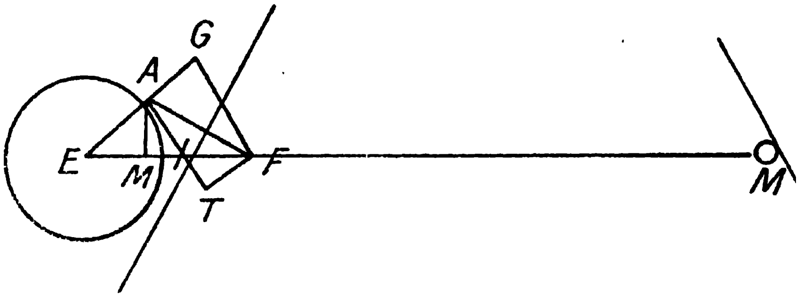

FIG. 55.

at right angles to gravity. The disturbing force is A F, which is resolved into A G, having no effect against gravity, and A T at right angles to gravity, and therefore unopposed by it, raising the water nearly six feet, and pulling away the air about three-quarters of a mile, and causing tremendous disturbance.

THE NEW METHOD OF EXPLAINING AND LOCATING SUN-SPOTS

During December 1900 Mr. Clements made certain predictions for the whole of the year 1901 with regard to sun-spots. These predictions he is at present unable to verify; the Creenwich spectroscopic and photographic results for that year are not yet published.

In the absence of that publication Mr. Clements was requested by the present writer to prove in some form or other that sun-spots are actually produced by planetary tidal action manifested at an angle of 45°. With this object in view Mr. Clements consulted the spectroscopic and photographic results published for 1899, the latest available. From this he has been able to construct a series of diagrams which, it may be hoped, will be effective and convincing.

Mr. Clements is quite satisfied that sun-spots are caused by planetary attraction. He has carefully examined all past sun-spot phenomena; he has not yet found any 'spot' phases that cannot be accounted for and explained by the planetary motions and the combined attraction of the planets upon the photosphere.

If we take Fig. 56, opposite, to represent the surface or the sun's hemisphere seen from the Earth, the line E M, E′M′, denotes the Earth's meridian, the longitude of the Earth as 218°, on April 28, 1899, and that of the sun 38°. The other planets are arranged round

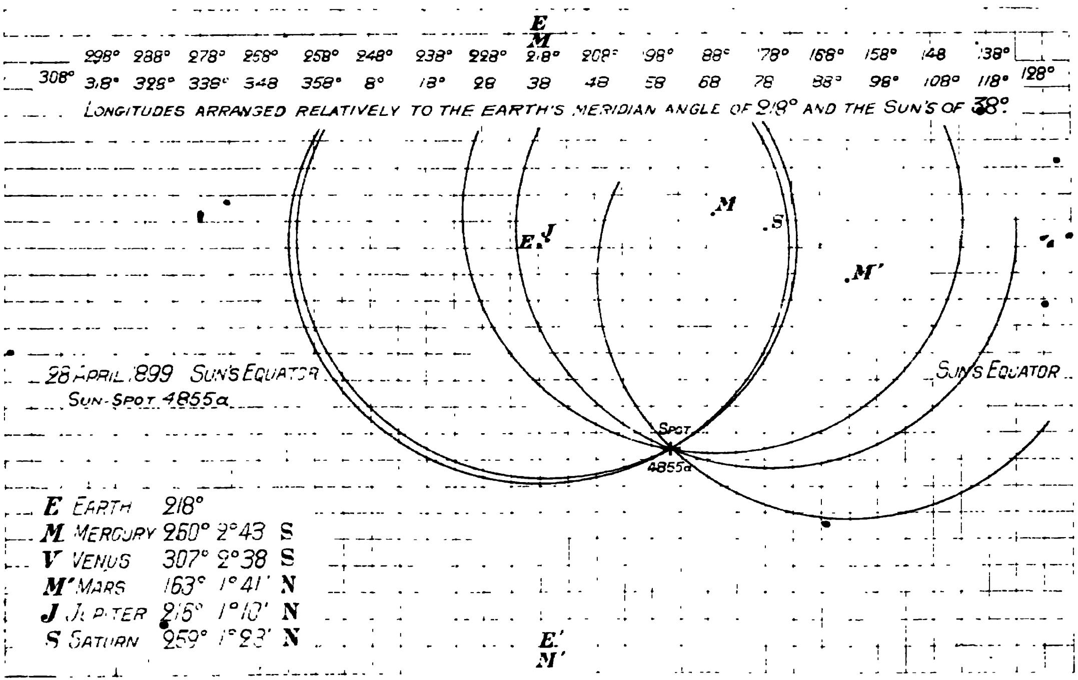

FIG. 50

PLANETARY INFLUENCE IN THE CAUSATION OF SUN-SPOTS

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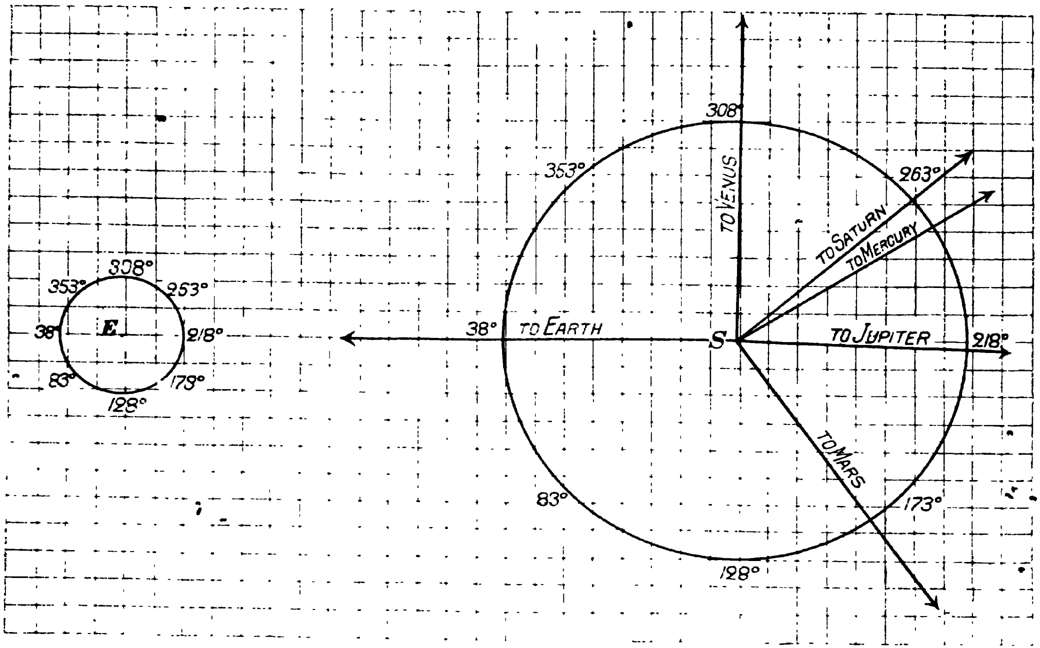

FIG. 57.
PLANETARY INFLUENCE IN THE CAUSATION OF SUN-SPOTS

To face page 217.

the sun as shown in Fig. 57, and their exact position with reference to longitude and latitude is given on Fig. 56. The spot on this fig. denoted by a cross, is in heliographic longitude and latitude of 61·2° and −12·7° and the positions of the planets Earth, Jupiter, Mercury, Saturn, and Mars are denoted by dots marked E, J, M, S and M′ respectively. These dots are supposed to represent the point on the sun's surface cut by a line joining the centre of the particular planet with the centre of the sun. From E, J, M, S and M′ curves are drawn at an angle of 45°, the angle at which the greatest tidal effect is produced, because at that angle the planet is pulling more or less at right angles to gravity and is therefore unopposed by it. In this case the spot occurs exactly at the intersection of these 45° tide-lifting curves where the photospheric solar envelope is pulled out and broken by the combined planetary pull, exhibiting comparative darkness beneath, —really diminished luminosity but less intensely brilliant than the photosphere.

The explanation given above as to the causation of the sun-spot on April 28, 1899, will generally apply to the spots of May 23 (Fig. 58); June 15 (Fig. 59); September 27 (Fig. 60), October 27 (Fig. 61); November 15 (Fig. 62); and December 15, 1899 (Fig. 63). The position of the respective spots and of the planets, with the tide-lifting curves of the latter, are given in each case.

With regard to the sun it is most difficult to fix any position accurately, as there are no landmarks on its

surface, only a mass of fleeting photospheric clouds. The time of the rotation of the sun upon its axis is not exactly known, neither is the angle of the plane of the sun's rotation with that of the Earth's orbit, nor the point where this plane cuts the ecliptic, nor the inclination of the sun's axis with the plane of the ecliptic. When we consider that the sun's equator makes an angle of upwards of 7° with the ecliptic and when we also consider that the Earth's equator makes an angle of over 23° with the ecliptic, we have here a divergence of 30° with regard to the Earth; there is a similar divergence so far as the other planets are concerned which causes the line from a planet to the sun's centre to cut the photosphere so far north or south of the equator. Therefore, having the exact points on the solar surface where the line joining the centres of the planets with the sun's centre cut the solar surface, we can localize sun-spots, and, conversely, from observed sun-spots, we can localize the exact distance of the planet north or south of the solar equator. In fact, by means of these sun-spots, we shall now, with the aid of the maximum tide-lifting curve of 45°, be able to assign accurate values to certain solar constants that have heretofore baffled human ingenuity.

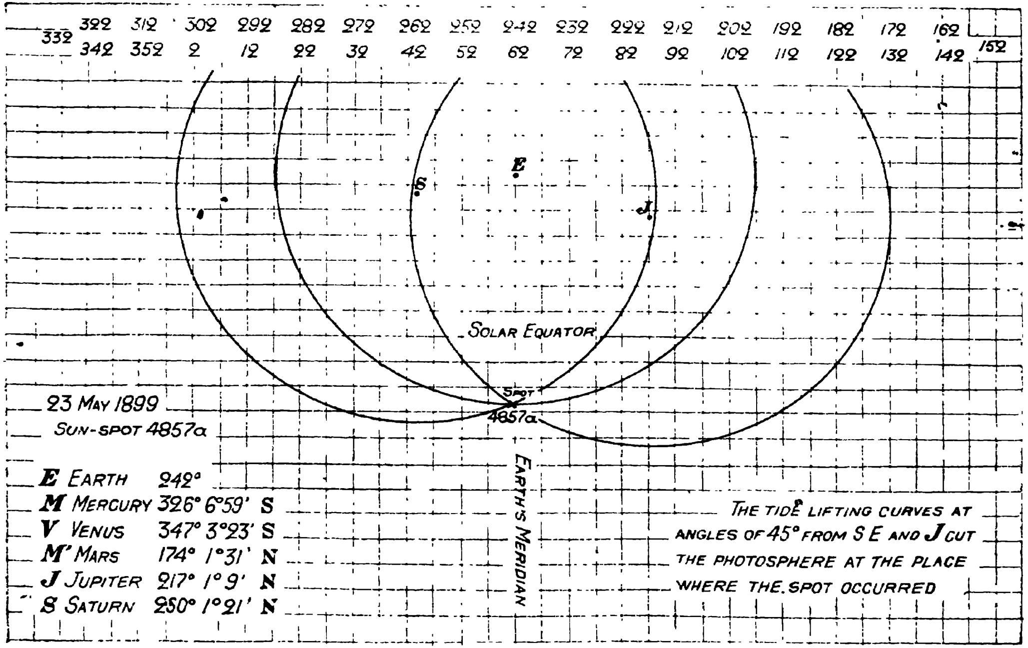

FIG. 58

PLANETARY INFLUENCE IN THE CAUSATION OF SUN-SPOTS.

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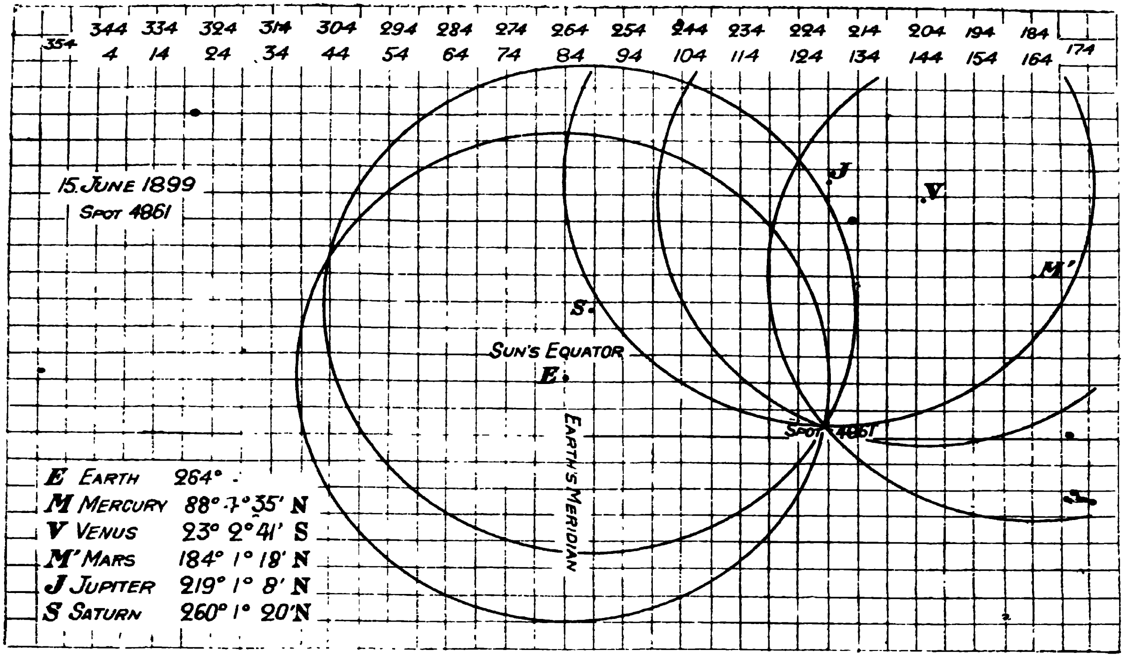

Fig. 59.

PLANETARY INFLUENCE IN THE CAUSATION OF SUN-SPOTS

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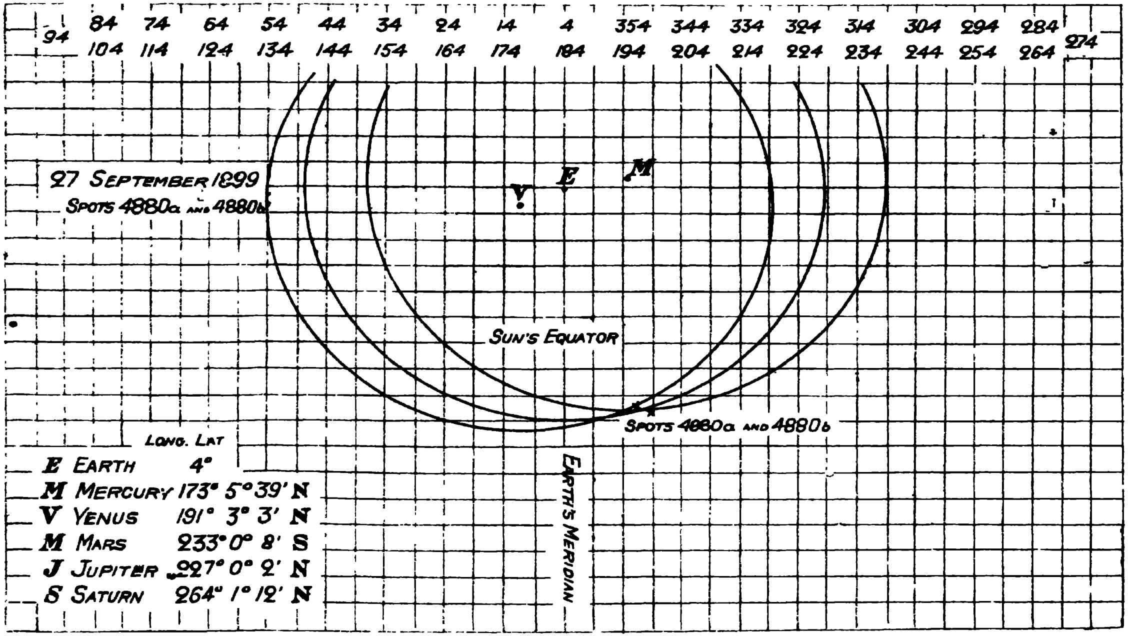


Fig. 60.

PLANETARY INFLUENCE IN THE CAUSATION OF SUN-SPOTS.

To face Fig. 59.

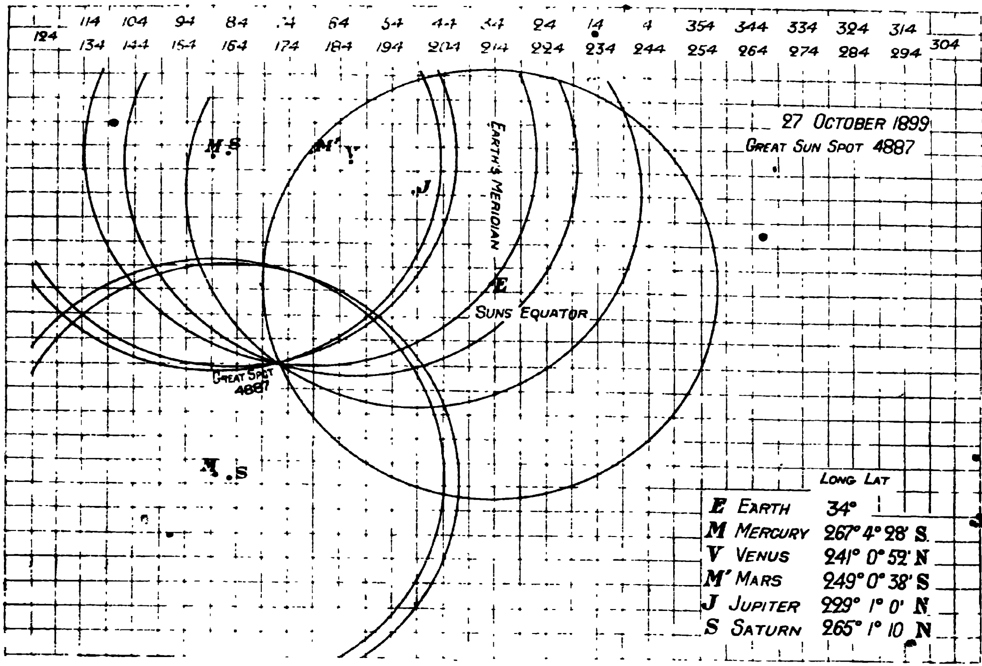


Fig. 61.
PLANETARY INFLUENCE IN THE CAUSATION OF SUN-SPOTS.

To face Fig. 62.

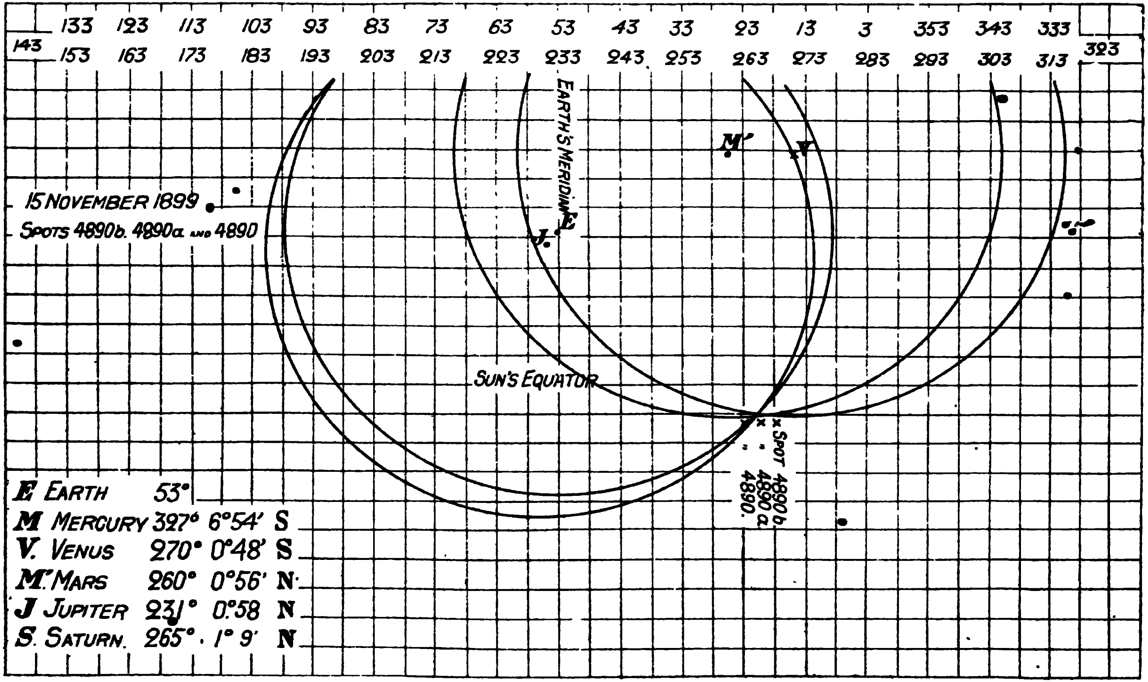


FIG. 62.

PLANETARY INFLUENCE IN THE CAUSATION OF SUN-SPOTS.

To face Fig. 62

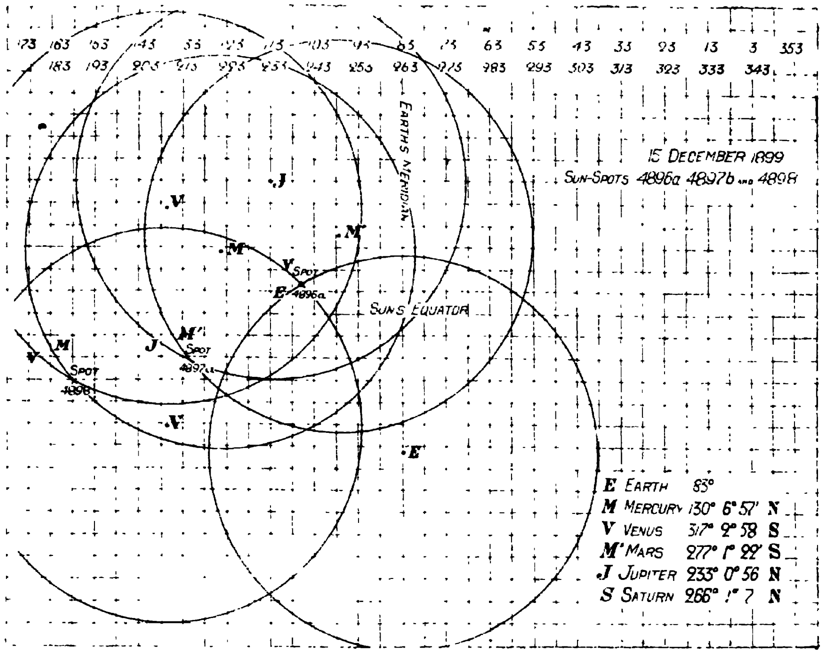


Fig. 65.

PLANETARY INFLUENCE IN THE CAUSATION OF SUN-SPOTS

To face page 2__

CHAPTER VI

The History of Meteorological Science

Scientific Ardour in England by Non-professional Men of Science (*The Times* on).
First Step in Meteorological Science Taken by a Greek 2,500 Years Ago.
Discoveries by Meton and Hipparchus, and later by Aristotle and Theophrastus.
Cicero and Virgil Keen Weather Observers.
Fourteen Hundred Years of Absolute Neglect.
The Inquisition of Intolerance which Exists in the Twentieth Century.
Founding of the Greenwich Observatory.
Researches into Planetary Motions by Newton, Kepler, Lagrange, and Laplace.
Orthodox Meteorology still in the Ptolemaic Stage of Knowledge.
Establishment of a Meteorological Department in England in 1854.
Weather Forecasts being Without Scientific Basis Stopped in 1866, but Afterwards Resumed.
Limitation of the Inquiries of the Meteorological Office.
Eight Fellows of the Royal Society Constitute a Board of Control over Meteorological Work.

Appendices :

I. The British Weather Bureau : Statement of Provisions for the Supply of Information to the Public.
   (*a*) Telegraphic Information ; List of Stations to which Storm Signals are Sent.
   (*b*) Information received Weekly ; Meteorological Statistics for Agricultural and Sanitary Purposes ; Weekly Weather Report, with Monthly and Annual Appendices.
   (*c*) Information from Other Stations in the British Isles.
   (*d*) Information from Land Observations outside the British Isles.
   (*e*) Marine Observations.

II. The United States' Weather Bureau :
   (*a*) Details Furnished by the Chief of the Bureau.
   (*b*) The Appropriation for Meteorology Increased Six Hundred Times in Thirty Years.

(*c*) A Great Record of Achievements, especially on the Great Lakes, and on the Sea.
(*d*) A Noble Recital of Accomplished Good.
(*e*) Observing Stations in Operation during 1900–1.
(*f*) Climate and Crop Service.
(*g*) Free Deliveries of Weather Intelligence by the Postal Department.

III. 'Meteorology and the Position of Science in America':-
Professor Cleveland Abbe's Article in the *North American Review*.
Position of Science in America.
What Has Been Done; What is Being Done; What Should be Done; the Future of Meteorology.

'The late Dr. J. H. Gladstone, F.R.S., belonged to a class of scientific workers which is nowhere so numerous as in this country, the class who, without being in the ordinary sense professional men of science, pursue scientific studies with professional ardour, devoting to them the leisure and the means which tempt other men to a life of amusement. English science owes much to men of that stamp, such as—to name only recent instances—Spottiswoode, Joule, and De la Rue, and it may be hoped that such disinterested workers will not be wanting in the future.'—*The Times*, October 8, 1902.

THE first step in meteorological science was taken when Meton, a Greek who lived in the sixth century B.C., discovered the metonic cycle of 19 years, during which time the new and full moons are repeated on the same dates of the months, and eclipses occur in the same order. And, in about five months less time, or a little over 18·6 years, there is a retrograde motion of the moon's nodes along the ecliptic, during which time the moon oscillates 5° on each side of the ecliptic, so that the declination of the moon varies from 18°30′ to 28°30′ north and south of the Equator, and has a great effect upon the air-pressure, as indicated by the barometer at any place.

The next step in the solution of the weather was taken when Hipparchus discovered that the moon's line of apse moved forward about 40° each year, so that a complete revolution was made in 8·86 years. This motion exerts a considerable influence upon air-pressure, and therefore upon the weather.

In the fourth century B.C., Aristotle, with his pupil

Theophrastus, collected and systematized all the weather-lore of prior ages that had been traditionally handed down, and it is on record that Cicero and Virgil were keen observers of the weather.

There was a long break of about fourteen hundred years, during which the human mind seemed to sleep, becoming resuscitated to some extent during the sixteenth century, when Copernicus, from a study of the Ptolemaic system of the Universe, arrived at the conclusion that the earth moved. His ideas, embodied in a big and very learned book, made little progress, because the mind of man was dominated by a spiritual and superstitious terrorism which was so powerful, in even the following century, that Galileo was forced by the threats of the Inquisition to renounce his conviction that the earth moved.[1]

The Greenwich Observatory, founded in the seventeenth century by Charles II, by constant observation of the moon for about one hundred and fifty years, has reduced the errors in her predicted places to a minimum, so that the differences in the predicted places of the moon agree with the corresponding differences in air-pressure. Kepler, also in the same century, so greatly increased our knowledge of the planetary motions that Newton, in 1687, was able to announce in the *Principia*

[1] There is no Inquisition now sufficiently powerful to bar scientific progress, but, so far as meteorology is concerned, there is a scientific intolerance of any argument in favour of moon-produced weather which almost universally dominates the Press, and boycots the individual who has the presumption to entertain heretical views. But, in this case, as in so many instances during the past, the heterodoxy of the nineteenth century will become the orthodoxy of the twentieth century. The barometer invented by Torricelli in the seventeenth century, as an instrument of precision for measuring the varying air-pressure caused by equally varying tidal action of the moon, will be mainly instrumental in upsetting the doctrine that the moon has no perceptible influence on the weather.—H. C.

his discovery of the principles of gravitation, which was developed and established as a natural law by Lagrange and Laplace, the great French mathematicians. By this law of gravitation, the lunar theory has been worked out, and by it the moon's place can at any time be predicted to within 2″. By inferences from the unseen and by the law of gravitation the system of Ptolemy, which taught that the earth was at rest with the sun and stars going round it, was overthrown. That system falsely explained, and attempted to predict, the movements of the heavenly bodies by appearances, cycles, epicycles, etc. Meteorology, unfortunately, is still in the Ptolemaic stage, and the weather is still inexactly explained and wrongly predicted by appearances, cyclones, anti-cyclones, V-shaped depressions, wedges, etc.

Many attempts were made during several centuries to predict the weather, but nothing officially was done in England until 1854, when a Meteorological Department of the Board of Trade was established under Admiral Fitzroy, mainly to aid the Mercantile Marine. In 1859 the British Association recommended the announcement of storms that were actually in progress, by telegraph, to places where they might be expected, but no predicted storm-warning was issued till early in 1861.

In the following August the publication of forecasts of the weather was commenced and continued till Admiral Fitzroy's death in 1865. In 1866 the Government stopped their publication, and referred the whole matter of forecasting to a committee of three scientific men. The committee reported that 'there is as yet no scientific basis for these daily forecasts, which are not correct, and there is no evidence of their utility. The Meteorological Office could not tell what weather would prevail during the next two or three days, nor when a storm would occur.'

Notwithstanding this adverse report the Meteorological

Office was re-established in 1867 under eight Fellows of the Royal Society, who constitute a Board of which Lieut.-General Sir Richard Strachey, R.E., G.C.S.I., is chairman, and Mr. R. H. Scott is secretary. Since then the daily weather-predictions have been maintained, and recently Mr. W. Napier Shaw has been appointed in Mr. Scott's stead.

Since Admiral Fitzroy's time there appears to have been little improvement in the daily weather-forecasts, and, so recently as December 1901, the forecast of the Meteorological Office was wrong twelve days out of thirty-one days with regard to rainfall alone, and the conclusion of the Committee of 1866 is still as true as it was then.

To this chapter are appended full particulars of the Meteorological Office of the United Kingdom, reprinted from the official publication, and a synopsis of the operations of the Weather Bureau of the United States. Were the Clements discovery and appropriate action upon it accepted as the rule of practice in the offices of the respective countries the benefits conferred upon humanity on sea and land would be beyond easy telling.

APPENDICES

I

THE METEOROLOGICAL OFFICE,
63, *Victoria Street, London, S.W.*

STATEMENT OF PROVISIONS FOR THE SUPPLY OF INFORMATION TO THE PUBLIC

COUNCIL

Directors:

Lieutenant-General Sir Richard Strachey, R.E., G.C.S.I., LL.D., F.R.S., Chairman.
Mr. Alexander Buchan, M.A., LL.D., F.R.S., F.R.S.E.
Professor George Howard Darwin, M.A., LL.D., D.Sc., F.R.S.
Rear-Admiral Sir William J. L. Wharton, K.C.B., F.R.S., Hydrographer to the Admiralty.
Mr. William Napier Shaw, M.A., F.R.S., Secretary.

Other Members of the Council:

The Earl of Rosse, K.P., D.C.L., LL.D., F.R.S.
Mr. John Young Buchanan, M.A., F.R.S., F.R.S.E.
Mr. William Henry Dines, B.A., Pres. Roy. Met. Soc.
Professor Arthur Schuster, Ph.D., F.R.S., F.R.A.S.
Mr. Robert Henry Scott, M.A., D.Sc., F.R.S.

The Meteorological Office was established in the year 1867 under the control of a Committee appointed by the Royal Society, at the instance of the Board of Trade, the Admiralty, and the Treasury, to take over the duties of the Meteorological Department of the Board of Trade, which had been established in 1854.

The Office was accordingly charged with the duty of collecting meteorological reports by telegraph from stations in the British Isles and their immediate neighbourhood, with a view to the issue of storm-warnings and forecasts of weather; of collecting for public use statistics about the weather from

land stations in the British Isles and elsewhere as well as from ships of the Royal Navy and the Merchant Service; and of promoting the practical applications of the science of meteorology by special researches.

A parliamentary grant was assigned for the maintenance of the Office. Changes have been made from time to time in the arrangements, and the control is now vested in a body of Directors appointed by the Royal Society.

The Office receives a large number of daily reports, and has gradually accumulated a valuable store of information about the weather in all parts of the world. The arrangements specified below have been made to enable the public to take advantage of this information.

The Office is open for general inquiries between the hours of 10 a.m. and 4 p.m. on week days (Saturdays, 1 p.m.), and for telegraphic inquiries from 8.30 a.m. to 8 p.m. on week-days, and from 6 to 8 p.m. on Sundays.

A. Telegraphic Information

Daily Weather Reports. Forecasts and Storm Warnings

Between 8.30 a.m. and 10 a.m. telegraphic messages are received daily, reporting meteorological observations at 25 stations (*see* list of stations, p. 15) in the British Isles, chiefly on the coast, and at 29 stations on the Continent of Europe. The observations in the British Isles are made at 8 a.m., and on the Continent partly at 7 a.m. and partly at 8 a.m. A certain number of stations report evening observations (6 p.m.), also by telegram, and those that do not report in the evening include the evening observations with the following morning reports, so that a complete schedule of morning and evening observations is drawn up daily. The information refers to the readings of the barometer; dry and wet bulb thermometers; maximum and minimum thermometers; rainfall and, in some cases, sunshine, with estimates of the direction and force of the wind, and reports of the weather and state of the sea.

These reports are supplemented by telegraphic reports from the Azores, through the courtesy of the Portuguese Government, by a number of additional observations made at various stations in the United Kingdom, and sent either by telegram or by post through the courtesy of private per-

sons or local officials. Moreover, the *Bulletin International*, published in Paris, reproducing meteorological telegrams from the whole of Europe, is received by post on the morning of the day after publication, and supplements the information previously received in the Office by telegram.

The telegraphic information is tabulated and charted by about 10 a.m. for the morning observations, and 7 p.m. for the evening ones. A general report is then drawn up, and forecasts of the weather for the twenty-four hours following the next noon, or midnight, as the case may be, are formulated.

A Daily Weather Report, which includes a transcript of the observations for the day, with some of those for the previous day, illustrative charts, descriptive remarks on the state of the weather, and forecasts for the several districts of the British Isles, is prepared for press and sent to the lithographers at 12 noon daily, except Sundays and Bank Holidays. It is ready for issue by 2 p.m., and is then delivered by hand or posted by book-post at 2.30 p.m. to those addresses which can be reached in the regular course of post on the same day. Copies for those who are outside this limit are posted by the evening mails.

The Daily Weather Report may be obtained on payment at the Meteorological Office of a subscription (for not less than a quarter of a year ending at the official quarter-days, e.g., March 31, June 30, etc.) at the rate of £1 per annum for delivery by book-post, £2 for delivery, where feasible, by hand. Single copies, price 1*d*. each, can be obtained after 3 p.m. on the day of issue at the Office, and at Messrs. W. H. Smith & Son's railway bookstalls at the following terminus stations :—Victoria, Charing Cross, King's Cross, St. Pancras, Euston.

Subscribers for the Daily Weather Report receive monthly lists of 'Corrections and Additions,' and occasional supplements, giving statistical meteorological results for the stations sending daily telegraphic reports.

Special advance copies of the descriptive remarks on the state of the weather and the forecasts, based upon the morning or evening observations, are prepared at 11 a.m. and 7.30 p.m. respectively, and are supplied gratis to the representative of any newspaper or press agency calling for them at the Office at the hours named.

As far as practicable the Council make arrangements for daily or weekly reports of the state of the weather in special form, upon terms which may be had upon application at the Office personally or by letter.

Printed copies of the morning forecasts for all districts are ready at 11 a.m., and are distributed by hand to clubs and societies situated in or near Pall Mall at a charge of 10*s.* per annum. They are sent by post at a charge of 2*s.* 6*d.* per official quarter or any part thereof, in addition to the cost of transmission. Copies of the evening forecasts are sent by post for a similar charge.

For the purposes of the forecasts of weather the British Isles are divided into eleven districts, as indicated in the accompanying map. A written copy of the latest forecast for a single district can be obtained at the Office between 9.30 a.m. and 8 p.m. upon payment of 6*d.* A written copy of the latest information in possession of the Office as to the state of the weather in any district of the British Isles, and for the neighbouring parts of the continent of Europe, can be obtained in like manner. The latest reports, with a map, are exhibited as early as possible for the information of the public at the entrance to the Office, and abbreviated reports for a few coast stations are displayed in the street on the balcony of the Office.

0. Scotland, North.
1. Scotland, East.
2. England, N.E.
3. England, East.
4. Midland Counties.
5. England, South, and English Channel.
6. Scotland, West, with Isle of Man.
7. England, N.W., with North Wales.
8. England, S.W., with South Wales.
9. Ireland, North.
10. Ireland, South.

By arrangement with H. M. Postmaster-General the latest information as to the state of the weather in various parts of the United Kingdom, or the Continent, and forecasts for one day in advance can be obtained from the Meteorological Office, upon payment at any Postal Telegraph Office of a fee of 6*d.* in addition to the cost of a telegram of inquiry addressed "Weather, London," and of the reply. Ten words, in addition to the address, must be allowed for the reply.

Telegrams of inquiry should state the nature of the infor-

mation required, and the name and address to which the information is to be sent, as in the following examples :

To " Weather, London."
Latest Information from [Straits of Dover].
or,
Latest Forecast for [Forfarshire].
or,
Next Forecast for [Dublin].
From (Name), (Address).

The latest information for any district, or the latest forecast, will be sent by telegraph to any address if a request be received by post stating when the information or forecast is to be sent, and enclosing 6*d*. in addition to the cost of a telegram, allowing ten words in addition to the address. It should be noted that forecasts are prepared for issue at 11 a.m. and 7.30 p.m.

Forecasts for a single district will be sent regularly to public bodies for exhibition without any charge beyond the cost of the telegrams, and to private persons at additional charge of 3*d*. per telegram for a forecast for a single district, and 6*d*. for two or more districts.

The Council have made arrangements for a special service of afternoon reports during the season of the Hay and Corn Harvests (June 1 to September 30), whereby they are enabled to issue a special series of forecasts daily (Sundays excepted) at 3.30 p.m. The forecasts for any district are supplied by telegraph to agriculturalists and others upon prepayment of the cost of the telegrams (nine words daily, in addition to the address) for the period during which the forecasts are required. Forms of application for these forecasts can be obtained at the Office.

The Postmaster-General has sanctioned the exhibition of forecasts at Local Post Offices, provided space is available, if the persons to whom they are addressed desire them to be so exhibited.

As far as practicable the Council, upon application, will make arrangements for the transcription of the whole or a selection of the morning or evening telegraphic reports, to be sent by telegraph, in code form, to newspapers or public associations desiring to make use of this means of accelerating the distribution of the latest information about the weather.

The special terms for this service can be obtained on application to the Office.

STORM-WARNINGS

The Office issues notices of threatening atmospherical disturbances on or near the coasts of the British Islands (free of charge) to ports and fishing stations recommended by responsible local authorities.

The fact that one of these notices has been received at any station is made known by hoisting a black canvas cone, 3 feet high, and 3 feet wide at base, which has the appearance of a triangle when hoisted. The telegram directing the cone to be hoisted is exhibited near the signal staff.

At dusk, whenever a signal ought to be flying if it were daylight, a night signal, consisting of three lanterns hung on a triangular frame, may be hoisted in place of the cone.

The Meteorological Office supplies the canvas cone, but does not undertake to supply the lanterns. In all cases the local authorities must undertake the charges incidental to the hoisting of the signal, such as flagstaff and gear, oil, etc., and also as to the keeping of the apparatus in repair, painting, etc.

The following is a list of the stations to which storm-warning telegrams are sent :

NORTHERN	WESTERN	SOUTHERN	EASTERN
SCOTLAND, N.E.	IRELAND, S.W.	ENGLAND, S.W.	ENGLAND, N.E.
Lerwick	Tuskar L.H.	The Lizard	Berwick - on-Tweed
Scalloway	New Ross.	Falmouth	Cullercoats
Dunrossness	Dunmore East	Pendennis	Tynemouth
Sumburgh Hd. L.H.	Dungarvan	Mevagissey	South Shields
Noup Head L.H.	Minehead L.H.	Mount Batten	Souter Point L.H.
Stromness	Youghal	Plymouth	Sunderland
Kirkwall	Queenstown	Devonport	Hartlepool
Cantick Head L.H.	Cork	Prawle Point	Middlesborough
Holborn Head	Passage	Teignmouth	Redcar
Dunnet Head	Kinsale	Exmouth	Whitby
Wick	Do. (Old Head)		Filey *
Tarbet Ness L.H.	Galley Head L.H.		Flamborough Head
Avoch	Castletownsend		Bridlington
	Fastnet Rock L.H.		

NORTHERN	WESTERN	SOUTHERN	EASTERN
Inverness	Brow Head		Hull
Nairn	Tralee		Goole
Burghead	Limerick		Grimsby
Lossiemouth	Loophead L.H.		Boston
Buckie	Galway		
Port Knockie			
Cullen	IRELAND, N.W.		
Portsoy	Killybegs L.H.		
Banff	Tory Island L.H.		
Fraserburgh	Lough Swilly L.H.		
Peterhead	Rathmullan		
Aberdeen	Malin Head		
Girdleness L.H.	Portrush		
	Port Ballintrae		
	Ballycastle		
SCOTLAND, E.	IRISH SEA.	ENGLAND, S.	ENGLAND, E.
Stonehaven	Belfast	Guernsey	Sutton Bridge
Montrose	Donaghadee	St. Helier's (Jersey)	Lynn
Scurdy Ness L.H.	Burr Point	Gorey ,,	Sheringham
Broughty Ferry	Howth	Portland L.H.	Cromer
Dundee	Kingstown	Weymouth	Gt. Yarmouth
St. Andrew's	Pt. of Aire (I.M.)	Anvil Point L.H.	Southwold
Anstruther	Ramsey ,,	Poole	Orford Ness L.H.
Pittenweem	Douglas ,,	Hurst Castle L.H.	Ipswich
Buckhaven	Castletown ,,	Southampton	Harwich
Methil	Silloth	Hamble	Gunfleet L.H.
Wemyss, West	Maryport	Yarmouth	
Burntisland	Workington	Cowes	
Grangemouth	Whitehaven	Ryde	
Bo'ness	Barrow	St. Catherine's Point	
Granton	Walney I. L.H.	Portsmouth	
Newhaven	Morecambe	Littlehampton	
Leith	Fleetwood	Brighton	
Fisherrow	Blackpool	Newhaven	
Dunbar	Lytham		
Cockburnspath	Southport		
St. Abb's Head	Formby		
Eyemouth	Liverpool		
	Runcorn		
	Hoylake		
	New Brighton		
	Connah's Quay	ENGLAND, S.E.	
	Penmaenmawr	Beachy Head	
SCOTLAND, N.W	Port Penrhyn	Eastbourne	
Fair Isle L.H.	Point Lynas L.H.	Hastings	
C. Wrath L.H.	Skerries L.H.	Rye	
Stourhead L.H.	Holyhead	Sandgate	
Port of Ness	South Stack L.H.	Folkestone	
Stornoway		Dover	
		Deal	

NORTHERN	WESTERN	SOUTHERN	EASTERN
Island Glass L.H.	Caernarvon	Ramsgate	
Portnaguiran	Port Dinorwic	Margate	
	ST. GEORGE'S CHANNEL	Faversham	
	Aberystwith	Sheerness	
	Milford	Chatham	
		Greenhithe	
SCOTLAND, W.	BRISTOL CHANNEL.		
Glasgow			
Greenock	Small's L.H.		
Rothesay	Caldy L.H.		
Lamlash	Pembrey		
Carradale	Llanelly		
Campbelton	Swansea		
Mull of Cantire L.H.	Briton Ferry		
	Porthcawl		
Rhuvaal L.H.	Nash L.H.		
Rhinns of Islay L.H.	Penarth		
	Cardiff		
Ardrossan	(Bute Dock)		
Girvan	Do. (Barry Dock).		
Ballantrae			
Cairn Ryan	Newport		
Corsewall Point L.H.	Weston-super-Mare		
Mull of Galloway L.H.	Burnham		
	Bridgewater		
	Lundy Island		
	Ilfracombe		
	Bull Point L.H.		
	Barnstaple		
	Appledore		
	Hartland Point L.H.		
	Boscastle		
	Port Isaac		
	Newquay		
	Hayle		
	Godrevy L.H.		
	St. Ives		
	St. Sennen		
	Newlyn, West		
	Penzance		
	Scilly		

B. Information Received Weekly

Meteorological Statistics for Agricultural and Sanitary Purposes

Weekly Weather Report, with Monthly and Annual Appendices

The Weekly Weather Report, which has been continued in its present form since 1890, is published on Thursdays, and gives, for the week ended on the preceding Saturday, a summary of temperature, rainfall, and duration of bright sunshine in the United Kingdom for agricultural and sanitary purposes. To this is added a series of maps showing the distribution of pressure and wind over the whole of Europe at 8 a.m. and 6 p.m. on each day, and the temperature, weather, and sea disturbance at 8 a.m. each day. The maps for each day are accompanied by a brief account of the distribution of weather for the day and the changes that have taken place. There is also appended a general summary of the weather over Europe for the week.

For the maps and descriptive account, the daily telegraphic reports are used, and are supplemented by the information contained in the *Bulletin International*, already referred to (p. 2), so that the area represented is much larger than that covered by the Daily Weather Report.

For the statistical summaries, the information from the twenty-five telegraphic reporting stations in the British Isles is supplemented by weekly returns of daily observations of maximum and minimum temperature and rainfall supplied by volunteer observers from thirty-seven other stations, marked F in the list on pp. 16 to 21, and by a number of observations of duration of bright sunshine at stations marked S on the list, which brings up the number of stations making sunshine returns to sixty-eight. The summaries refer to districts which are identical with the forecast districts of the Daily Weather Report, and they are grouped into wheat-producing districts and grazing districts.

In the data for temperature are included not only statistics of mean and extreme temperatures for the week, but also weekly and progressive statistics of accumulated temperature, of which the following brief explanation may be given.

The tables of *Accumulated Temperature* are designed to give persons engaged in agriculture better means for estimating the manner in which vegetation is affected by temperature than that afforded by the more usual methods of treating the readings of the thermometer. They show for each week, and for the whole period from the beginning of the year, the weekly and progressive values respectively of the combined amount and duration of the excess or defect of the air-temperature, above or below a suitably fixed standard, or *base temperature.* The base value adopted is 42° Fahr.

Accumulated Temperature is expressed in *Day degrees*, a Day degree signifying 1° F. of excess or defect of temperature above or below the base (42° F.) continued for twenty-four hours, or any other number of degrees for an inversely proportional number of hours.

The following are the rules for computing, from the observed maxima and minima, the accumulated temperature above or below 42° F. for a weekly period :

1. Obtain the mean temperature, from the means of the seven observed maxima and minima, suitably corrected for non-periodic changes of temperature.

2. In obtaining the accumulated temperature four cases may occur, to which the following rules will apply :

In each of the above cases the result will be the average *daily* value, and must be multiplied by seven in order to obtain the value for the whole week.

The coefficient varies with the duration of the period, and also with the base temperature.

The coefficient given in the second and third rules of the preceding table is for a weekly period, and for the base temperature 42° F. The following are its values for other base temperatures : for 32° F., 0·4 ; for 52° F., 0·33 ; for 62° F., 0·25.

Subscribers for the Weekly Weather Report receive also the following supplements and appendices.

I. *A Monthly Supplement* giving (1) a climatological summary of the observations at the Telegraphic Reporting Stations ; (2) a summary of maximum and minimum temperature, rainfall, and sunshine at the additional stations which furnish weekly returns. In the case of instrumental observations a comparison with the average is included in each of these summaries. (3) Four maps showing the average distribution

Conditions of Temperature.	To obtain the daily Accumulated Temperature.	
	Above 42° F.	Below 42° F.
If the minimum is *above* 42° F., or *equal* to 42°F.	Subtract 42° F. from the mean.	There is none.
If the minimum is *below* 42° F., but the mean for the day is *above* 42° F.	From the difference between mean for the day and the minimum deduct the accumulated temperature below 42° F., calculated as stated in the next column.	The required quantity is the excess of 42° F. over the minimum, multiplied by the coefficient 0·4.
If the mean for the day is *below* 42° F., but the maximum is *above* 42° F.	The required quantity is the excess of the maximum over 42° F., multiplied by the co-efficient 0·4.	From the difference between the mean for the day and the minimum deduct the accumulated temperature above 42° F., calculated as stated in the preceding column.
If the maximum is *below* 42° F., or *equal* to 42° F.	There is none.	Subtract the mean from 42° F.

of barometer and wind, the movements of barometric depressions, the distribution of mean temperature, and the distribution of rainfall.

II. *Appendix I.* Containing (1) a quarterly and annual summary of rainfall and mean temperature of each district compared with the corresponding quarter of the whole year for each of the past ten years, and with each of the corresponding five yearly means for thirty-five years;

(2) A table of the driest and wettest, the coldest and warmest corresponding quarters and years;

(3) Monthly totals of rainfall, accumulated temperature and sunshine, together with progressive totals for each month of the quarter.

III. *Appendix II.* Weekly and progressive totals of rainy days, rainfall, accumulated temperature, and duration of sunshine with percentage of possible amount for the whole year for the several districts.

IV. *Appendix III.* Appears every fifth year and gives

the weekly and progressive values of the different elements in each five years and for the whole period since 1881.

V. *Appendix IV*. Also appears every fifth year and gives for each district a comparison of the mean of the average temperature of successive weeks for the preceding five years with the corresponding value for the whole period defined above.

An advance copy of the MS. of the Report is prepared on Tuesday in each week, and is supplied free of charge to newspapers, together with the weekly summary which occupies the first page of the Report.

The Report is published every Thursday afternoon by the Publishers to the Stationery Office, Messrs. Eyre & Spottiswoode, East Harding Street, E.C., Oliver & Boyd, Edinburgh, and E. Ponsonby, 116, Grafton Street, Dublin. The annual subscription is £1 10s., post paid. Single copies are cold at *6d.* each, exclusive of postage, and the separate appendices are priced at from *4d.* to 1*s*.

C. Information from other Stations in the British Isles

The Council maintains a fully equipped meteorological Observatory at Valencia (Cahirciveen), Co. Kerry, Ireland. They have also established instruments and subsidised the observatories at Kew, Falmouth, Aberdeen, and those at the foot and the summit of Ben Nevis. They receive in return curves and hourly tabulations of pressure, dry-bulb temperature, wet-bulb temperature, rainfall, direction and velocity of the wind, together with sunshine records from the five observatories first named, and copies of the hourly readings from the summit of Ben Nevis.

An annual volume embodying the results of the observations at the five Observatories is published in the usual way. That for 1897 has recently been issued, price 37*s*. *6d.*

In return for an annual grant they also receive duplicates of the curves from the self-recording instruments at Glasgow, Armagh and Stonyhurst, and the tabulations of these curves are available if required.

Anemographic records are also received from Alnwick Castle, Deerness, Dublin, Kingstown, Holyhead, North Shields, Scilly and Yarmouth.

Sunshine records are received from sixty-four stations.

Normal climatological stations, 'equipped and maintained by volunteer observers or by local authorities at their own expense, supply monthly returns of readings of all the meteorological elements at 9 a.m. and 9 p.m.

The following extract from the complete Form will show the headings under which observations are recorded:

Twice daily (at 9 a.m. and 9 p.m.)																	Once daily.						
Barometer.			Temperature.				Humidity.[1]			Wind.		Cloud.			Weather.		Rain.		Temp.		Extra Observations.		
			As read.		Corrected.														Corrected readings at 9 p.m.				
Attached thermometer.	Uncorrected.	Corrected and reduced to 32° Fahr., at mean sea level.	Dry bulb.	Wet bulb.	Dry bulb.	Wet bulb.	Dew point.	Elastic Force of Aqueous Vapour	Percentage.	Direction.	Force (0–12).	Amount (0–10).	Form.	Direction of lower Stratum, whence coming.	At time of Observation.	Since last Observation.	At 9 a.m.	Estimated duration.	Max.	Min.	Duration of Bright Sunshine.	Weather Symbols.	Remarks.

[1] Deduced from readings of dry-bulb and wet-bulb.

An annual volume embodying the results of these observations is published; that for 1897 has recently been issued, price 22*s*.

Other Climatological Stations (including those which have already been referred to as contributing weekly returns) equipped and maintained in like manner, furnish periodical returns with less extensive information than that supplied by the normal climatological stations, or information of the same extent but with different hours of observation. Other stations furnish weekly readings of sea-temperature.

All the stations in the British Isles from which information of any kind is received, and a statement of the nature of the information, are given in the list of stations appended hereto, and are shown upon pp. 16 to 21.

Extracts from the returns thus collected, whether published in the manner described or in manuscript, are supplied to any person upon making written application to the Secretary, specifying precisely the details of the information required. For these extracts a charge is made to cover the cost of the

time required for selecting and making them. The information will, if required, be attested by a sworn declaration before a commissioner for oaths, at a fee of £1 1s. (in addition to the charge of 1s. 6d. made by the commissioner for oaths). A special fee of £2 2s. for each day's attendance is charged if a representative of the Council is required to attend in court to prove the statements contained in the extracts supplied.

D. Information from Land Stations outside the British Isles

Periodical returns are received by the Council from the stations in different British Colonies and dependencies, or in foreign countries, as follows: Antigua, Bahamas (six stations), Barbados, Beyrout, Falkland Islands, Cape Spartel, Colon, Cyprus (six stations), Fort Rae,[1] British Guiana, Gibraltar, Gold Coast (eight stations), Lagos, Madagascar, Port Natal,[1] St. Helena (three stations), Sierra Leone, Sombrero, Teneriffe.

A list of the documents received from these stations is given on pp. 25 to 27.

Extracts from these returns are supplied upon the same terms as those from the returns of British Stations.

E. Marine Observations

The information as to the meteorology of the sea collected by the Office since 1855 is contained in a large number of logs kept by the officers of His Majesty's ships, or of the Mercantile Marine, and forwarded to the Office. The information is regularly discussed and arranged according to the squares of latitude and longitude, embracing 10 degrees in each direction, and again sub-divided according to one degree squares. The information is then arranged statistically and is represented by a series of publications, of which a list can be obtained on application to the Office.

Commencing with April of the current year (1901), a series of Pilot Charts of the North Atlantic and Mediterranean is being issued. These are supplied by the Superintendents

[1] Observations from these stations are exceptional.

of the Mercantile Marine Offices at the principal British ports to captains and officers of merchant ships, at the price of 6*d*. each. Copies can also be obtained from the Publishers to the Stationery Office at the price of 5*s*. for an annual series of twelve charts, or 6*d*. for each chart; in addition to the cost of transmission.

The marine observations are by voluntary observers. Those officers whose names are on the list of observers for the Office receive the Pilot Charts free, and also receive from time to time copies of the other marine publications issued by the Office.

II

THE UNITED STATES WEATHER BUREAU

The organisation in the United States which deals with meteorological phenomena is a branch of the Department of Agriculture. Its history was told by its present chief, Willis L. Moore, in his presidential speech at the second convention of Weather Bureau officials held at Milwaukee, Wisconsin, in August 1901. 'It is interesting to recall,' said Mr. Moore, 'that in 1870 this weather-service had its inception. It is also interesting to note that the appropriation at that time was $20,000, and that to-day the people of the United States spend nearly one million two hundred thousand dollars annually for this service, and are satisfied with the expenditure, for the service has not been compelled to petition anybody for its maintenance for many years. Congress has freely given us every dollar we have estimated for in the past four years. Away back in 1870, and prior to that time, there were a few indefatigable workers whose object was the creation of an institution that was finally to send to Milwaukee such a convention as this. Dr. Lapham, whom every one in Milwaukee loved, was one of those earnest workers, gentle in his way and modest in his demeanour. He and our own Professor Abbe did more than any other two persons to create the present weather-service. Redfield, Espey, Loomis, Maury, Coffin, and other scientists, had demonstrated the theory of storms as we understand it to-day. Neither Lapham nor Abbe added materially to that theory, but Abbe collected

observations of the weather in 1869, with the aid of the Cincinnati Chamber of Commerce and the Western Union Telegraph Company, and began making forecasts for the purpose of giving an example of what could be done. Lapham collected records of some 2,000 disasters on Lake Michigan, the majority of which would have been averted had there been a weather-service. Lapham went to the National Board of Trade and there got resolutions. He made such a lucid argument with the facts that he presented that, finally, a Congressman from Wisconsin, General Halbert E. Paine, introduced in the Congress a resolution appropriating the $20,000, to which I have just referred.

'From that modest beginning has grown the weather-service of to-day. It embraces an area from the north coast of South America to the remotest confines of Canadian habitation, and from the Atlantic to the Pacific. It is the greatest survey of atmospheric conditions ever presented to the eye of the forecaster; and if meteorology, in its weather predictions, comes to be an exact science it will be due to the energy and liberality of the United States Government in presenting such a magnificent daily picture for the study of the meteorologist. If it ever comes to the time when we can forecast the character of the coming seasons, so that the farmer may conserve his energies and spend them to the most profitable advantage, it will be due to the scientific study of such a broad atmospheric picture as the United States daily presents. It will not be due to chance. It was a long time before we were entitled to the confidence of the marine interests. But to-day hardly a ship sails, the master of which does not take cognizance of the weather-map, daily forecasts, and storm-signals. Down in New Orleans, when the recent storm came in from the Gulf, our official issued warnings that the papers of New Orleans say reduced the wreckage on the open waters

at least $1,000,000. He was able to say to Galveston what was just as valuable to it as the storm-warning was to New Orleans, viz., "You need have no fear; this storm will go northward and not strike the Texas coast. Only don't let your vessels sail out into it." That reassured the Galveston people and prevented their being panic-stricken.

'We have erected at more than one-half the marine ports tall steel towers for the display of marine-warnings, where, before, the warnings were displayed from anything to which a lantern could be tied. We have experimented to determine the most powerful lantern we could make that would be suitable for our use. We have inaugurated in the lake-region what we call the lake marine service, with headquarters at Detroit, and we have made a study of the fog-areas, so that at different seasons of the year the mariner may know on what portions of the different lakes he will meet with the greatest percentage of fogginess. It was simply the establishment of the normal, that is all; but, by collecting the records from many vessels, we are able to say where, during certain seasons, there will probably be encountered the greatest amount of fog. The extension of the forecast system has been important. By co-operation with Mexico we now exchange observations with that country. By an extension of the service as an incident of the war with Spain, we now have a service which covers the West Indies and surrounds the Gulf of Mexico. By a recent arrangement with the English meteorological office we get daily observations from the west coast of Europe. By the completion of the German cable from Lisbon across to the Azores and thence to New York, we get observations from the Azores which are highly valuable in making warnings for the guidance of trans-oceanic steamers. The extension of the marine part of our work has resulted in enabling our forecasters to make fairly accurate ocean-

forecasts for outgoing steamers. We have to interpolate a little for the pressure of the North Atlantic, but it is found that our estimate is highly valuable to commerce, and is accurately made. Most of the things that I have referred to are important innovations that the marine interests have been seeking for years, and we are glad they have been obtained. Many other things that were discussed at our Omaha convention, as you know, have been incorporated in the weather-service. I think the most profitable instruction I have ever received as chief of this service came from listening to your discussions at that convention three years ago. This is a coming together of supervising officials. One rubs up against another, gathers his ideas, takes them home, and applies them to his own work. It is a sort of clearing-house for weather ideas.

'One of the last and most important innovations in the weather service has been accomplished through the co-operation of Mr. Machen, Superintendent of the Rural Free-Delivery Service. We have had the hearty co-operation of the Post Office Department, and to-day the small carriers going out into the rural districts carry with them little slips containing the daily forecasts, and Mr. Machen finds it one of the most popular features of the rural free delivery. This part of our work will be greatly extended in the future.

'There is another innovation that I hope to have made. I have not yet presented it to the Secretary of Agriculture, but I believe he will give it his approval, as he has always shown a disposition to favour anything that means help to the Weather Bureau. That is the construction of individual observatories in every city where we have a station. So far Congress has freely given us money to build separate meteorological observatories at isolated places on our various coasts. We are constructing six this year. I propose to place the matter

before Secretary Wilson, so that he may place it before Congress, with a view to completing a few buildings each year, so that in a city like Milwaukee there would be erected a Weather-Bureau building that would be in fact a Weather-Bureau observatory.'

OBSERVING STATIONS

STATIONS IN OPERATION DURING 1900–1

Taking two observations daily (all elements)	148
Taking one observation daily (all elements).. ..	20
Taking one observation daily (temperature, rainfall, wind and weather)	10
Taking one observation daily (temperature and rainfall only, *Cotton Region*)	124
Taking one observation daily (temperature and rainfall only, *Corn and Wheat Region*)	132
Taking one observation daily (river and rainfall only)	118
Taking one observation daily (rainfall only)	41
Total paid Stations	593
Voluntary Stations, about	2,500
Grand total	3,093

One is surprised that the number of voluntary stations is not larger. In the United Kingdom, British rainfall and other details are contributed to the *Meteorological Magazine* and to the annual volume entitled *British Rainfall*;[1] these have associated with them more than three thousand observers. The United States might have been expected to have many more voluntary recorders, considering the immensity of its territory, than has the United Kingdom.

[1] Edward Stanford, London.

CLIMATE AND CROP SERVICE[1]

From a meagre beginning in 1887, when the National Climate and Crop Bulletin did not exceed in size any one of the forty-four State Section bulletins now issued, the climate and crop service of the Weather Bureau has grown until to-day its several features constitute a work which, in the opinion of the speaker, is exceeded in importance and value by but one other branch of the Bureau's work, namely, the daily forecast and storm-warning service, which, I think we all must admit, is the Bureau's first and most important duty.

'With forty-two well organized State climatological services, besides those of Cuba and Porto Rico, we have a most efficient means for the collection and dissemination of information. We are amassing meteorological records from more than 3,000 stations, which, as well as providing for immediate use data required for current climate and crop publications, will prove of inestimable value to the future scientific investigator.

'Until recent years the filling of requests from the various sources for special data constituted no small item of work at the central office in Washington. Now practically all such requests are satisfactorily met by the monthly reports of climate and crop sections. Scarcely a question can be asked concerning the climatic features of any part of the country, however exact as to time and place, that is not readily answered by these publications.

'The national and the section climate and crop bulletins form a most complete history of the weather-conditions throughout the period of planting, cultivating, and harvesting of crops. Much more might be said with

[1] Second Convention of United States Weather-Bureau officials, August 1901. Address on Climate and Crop Service, by James Berry, Washington, D. C.

regard to the system by which our crop-work is conducted, but you are all familiar with it, and I will not consume time in dwelling thereupon.

'In our climate and crop work we should be powerless to accomplish much that is valuable without the co operation of our voluntary observers, display-men, and crop-correspondents, who give, without compensation, a part of their time each day, either in taking observations, distributing forecasts, or reporting the climate and crop conditions. Too much praise cannot be accorded these public-spirited citizens for the sacrifices made to aid in this important work.

'The foreign visitors, often the representatives of their respective Governments, calling at the Weather Bureau, invariably evince a lively interest in the crop-reporting system of the Bureau. They are favourably impressed with its thoroughness of conception and execution, and invariably express astonishment at the rapidity with which the work is accomplished, as well as admiration for its completeness.

'The establishment of voluntary meteorological stations and the issue of climate and crop publications is not the only work conducted by the State climatological sections. It is through them that arrangements are made for the dissemination of the weather-forecasts and special warnings. Nearly 2,000 forecast-telegrams are sent out at Government expense daily to carefully selected points throughout the country, and these dispatches are multiplied by the various means of dissemination until a grand total of nearly 150,000 weather bulletins are displayed daily in time to give the public information as to the expected weather-conditions of the succeeding day. In the dissemination of weather-information the co-operation of the Post-Office Department, which is cheerfully given, is indispensable. From the Postmaster-General down to the rural free-delivery carrier, our efforts in this direc-

tion are heartily seconded. Before the convention closes we will have with us Hon. A. W. Machen, the general superintendent of the free-delivery system of the Post-Office Department, who has taken a keen interest in forecast-distribution through the rural free-delivery mail-service of the Post-Office Department, and we have the best reasons for believing that his subordinates will assist, as far as they may, without detriment to the postal service, in further extending this work.'

FREE DELIVERIES OF WEATHER INTELLIGENCE BY THE POSTAL DEPARTMENT

'To what extent can rural free delivery be used to distribute weather forecasts is a question which no doubt deeply interests all weather-forecasters. Just before leaving Washington I had placed before me a statement showing the number of offices at which the Weather-Service could now be handled by rural carriers. About a month ago a general letter of inquiry was sent to post-masters at rural free delivery offices, about 2,600. Replies have been received from about 1,800. Of the 1,800 points, there are 464 which the carriers leave at ten o'clock or later for their routes, so that it will be possible at these offices to use the rural carriers to distribute forecasts as soon as the Weather Bureau can arrange to get the information to the postmasters, who will be authorized to stamp the cards. Four hundred and sixty-four out of 1,800 is about 25 per cent. On October 1 there will be 3,000 points in this country served by rural free delivery. At the same percentage it is seen that 750 offices may be reached by the weather-forecast system after that date. Averaging two carriers to the office means 1,500 carriers, who could deliver forecast-cards to about 150,000 farm families. That will make a pretty fair start. There are a number of other places at which, upon investigation, we may be able to detain the carrier until after ten o'clock.'[1]

[1] *Ibid.* Speech by A. W. Machen, p. 233.

III

'METEOROLOGY AND THE POSITION OF SCIENCE IN AMERICA'

THE science of meteorology, so far at least as its study is concerned, is taken much more seriously in the United States than it is in the United Kingdom. In the June (1902) number of the *North American Review*, Professor Cleveland Abbe, of the United States Weather Bureau, writes learnedly and lucidly on the subject quoted at the head of the paragraph.

Before entering upon his specific subject, however, Professor Abbe thinks it may be well to observe that we must avoid confounding two distinct ideas, viz. 'America's position in the scientific world' and 'the position of science in America.' The former (he remarks) is secure, the latter is still unsatisfactory; and it is the latter that we may seek to improve by practical means. 'It is not denied that America has thus far honoured her inventors more than her men of research. In popular esteem the practical is often put higher than the theoretical, because it comes nearer to the popular heart. The investigator is liable to be neglected in comparison with the teacher or the lecturer; and the latter, in turn, are rewarded and supported less liberally than the inventor or manufacturer. Even in Europe the great engineers generally receive more attention than the investigating physicists, although the latter lay the foundation for the work of the former. The same holds true in astronomy, chemistry, mechanics, and every other branch of science. The knowledge gained by investigation always has formed, and always will form, the only firm foundation on which to build up invention and all the arts of civilization. But it is folly to speak of one class of men as greater than the other; each is equally essential to the complete whole.'

WHAT HAS BEEN DONE:

'The older branch of meteorology, named climatology considered purely as a study of statistics, began in America about 1817, under the inspiration of Mansfield and Lawton; it was especially fostered by Henry in the Smithsonian, by Lovell as Surgeon-General, by Schott in the Coast Survey, by Watts the Commissioner of Agriculture, and it is now developed by the Weather Bureau. Maury's *Winds and Currents of the Ocean*, Coffin's *Winds of the Globe*, Schott's *Tables of Temperature and Rainfall*, were superior to any similar works published in Europe at corresponding dates. American citizens have also done great work in foreign countries—such, for example, as that of B. A. Gould and W. G. Davis on the climatology of the Argentine Republic. Many colleges and schools teach climatology; Harvard has an admirable school; Johns Hopkins and other universities have excellent courses on this subject.'

'In the younger branch of dynamic and physical meteorology, our countrymen and our Weather Bureau have been very conspicuous. James Pollard Espy of Philadelphia devoted his life to this subject, and it is impossible to speak of the progress of modern meteorology without mentioning him who is recognized everywhere as its founder.'

WHAT IS BEING DONE:

'At the present time, there are among meteorologists in America two men whose names are as well known in Europe as here—namely, Professor Marvin, skilful in the laboratory, and Professor Bigelow, accomplished in mathematical analysis. The same may be said of the meteorologists at the Blue Hill Observatory, where special attention has been given by Messrs. Rotch and Clayton to the study of the upper air. American work is worthy of the highest praise and has stimulated similar work in Europe. As regards organization and practical results, the United States Weather Bureau, under Professor Willis L. Moore, is doing the greatest and best work that has ever been done in any applied science; in its way, this Bureau is equal to the Pasteur Institute or anything else that Europe has to show. No European would deny that, in this respect, America is easily the first in the world.'

WHAT SHOULD BE DONE.

'We must increase our national activity in this respect. Our universities send forth annually perhaps one-tenth as many young men devoted to research as does Germany. It is a matter that needs no demonstration that there is about an equal proportion of youths of innate intellectual ability in America and in Europe, but these die like the wasted seeds unless circumstance contribute to their proper growth. I look upon the development of a genius among men as the florist looks upon a so-called "sport" among flowers; the latter grows wherever a seed of abnormal proclivities accidentally falls into a favourable soil and develops into a new variety of plant. Such were Copernicus, Tycho Brahe, Kepler, Newton and many other famous men. It is the province of our universities to nourish a host of post-graduate research students, in the confident expectation that here and there there will develop a genius that shall be a tower of strength.

'As the prospect of congenial employment encourages young men to do good work in hope of recognition, so the endowment of research, and a little assistance from trust funds administered in the interest of research, encourage the older men, and often decide whether a given study shall be undertaken or not. The past history of funds for the endowment of research will, I think, show that applications for assistance, as compared with the actual grants of aid, have been in the ratio of ten to one. The total number of applications, rather than of the grants, indicates the intellectual aspirations of our countrymen. It shows what our men wish to do, but are only able to accomplish when they have financial help. The administrators of these funds sometimes allow them to be expended on apparatus, at other times on incidental expenses, the hire of assistants, office rent, etc.; but they rarely authorize the responsible chief of the investigation to apply the money to his own living expenses. They proceed on the assumption that he has an income from his own fortune or from other daily work, and that the proposed research is a minor undertaking, additional to current duties. This policy results in withholding help from the young scientist, and forces the older ones to be very cautious in applying for help. The most important investigations demand much time, and the student should be free

from all other cares and completely devoted to the work in hand. It is certain that science has only received bountiful returns when her investigators have been supported steadily and with generosity, straight through the years of toil that their work required.

'The problem of stimulating research is not a new one in the United States. A small percentage of Smithsonian and Hodgkins funds has always been available, and similar smaller funds are in other hands. Several millions have also been invested in institutions intended for research and instruction, such as astronomical observatories, chemical and physical laboratories, geological, zoological and botanical museums of gardens, and scientific libraries. But the endowment of research results in important additions to our knowledge only when the right men are thereby set to work. Undoubtedly, America has several such men.

'The law of supply and demand applies to science as well as to commercial matters. If there be no demand for improvement, the improvements and the inventors retire alike into the background, or are altogether eliminated. The Patent Office has been organized to secure the rights of inventors and stimulate that side of our national progress. No analogous organization has as yet been established for the defence of the rights of the original discoverers. We have no national or federal recognition of the general principle that original research, the discovery of new laws or new elements, new stars or new truths of any kind in nature, is of any importance whatever to the individual or to the nation. However, our governmental departments do make appointments on the basis of work done in history, biology or physics, and this policy is bringing about good results.'

The Future of Meteorology.

'It is not to be denied that, at present, the progress of meteorology in this country depends very largely upon the encouragement given by the United States Weather Bureau to the highest class of scientific research. This Bureau centralizes the entire Government patronage in this respect. There is scarcely an observing station in the country that does not report to it. Its telegraphic organization for reports and daily forecasts reaches every point on the continent.

Its forty or fifty sections publish monthly, in great detail, the climatic data of each State and Territory. The whole service is recognized the world over as a model in respect to thoroughness, accuracy and promptness. Moreover, every one is stimulated by its chief to special study and work under the assurance that his personal ability will be recognized in some agreeable way. The Bureau is a purely Civil Service organization, but that does not mean that it does not need the spirit of progress. It needs to utilise men of research and men of progressive ideas in every branch of its work. Its daily routine of observing and forecasting is not in itself research. The experience of the Weather Bureau is like that of every other organization in the whole long history of science, to the effect that ability and success in research do not result from organization. The gift for research is a style of intellectual energy that refuses to be bound by regulations. An energetic investigator immured in the walls of a great organization may be as much out of place as a wild bird in a cage. He must have intellectual freedom. He can utilize, but must not be dominated by, his surroundings. His mind sees something better than is seen by others, something that is scarcely dreamed of by them. Nature gives him a glimpse of some one of her hidden possibilities, and he has the genius to follow the trail and convert his glimpse into a glorious reality for the rest of us. He studies nature, not policy. It is likely that there are many such men outside as well as inside, the service. In order to give this latent talent a chance to reveal itself, the Secretary of Agriculture has taken two important steps. As to the outside talent, he has established a corps of student assistants in all the varied branches of his great department. If these student assistants are chosen preferably from among the holders of the university degree of Ph.D., the greatest possible stimulus will be given to post-graduate work in the scientific schools throughout the land. In order to encourage the latent within the Meteorological Service, Secretary Wilson has encouraged Professor Willis L. Moore to give the broadest development to a modest periodical entitled *The Monthly Weather Review*. This opens its columns to all who are teaching, observing, or investigating, along the lines of Weather Bureau work, and, thereby, does something to stimulate research and progress. As to those employees of the service

who have already shown ability in research, but are much encumbered with executive and routine work, we can only hope that times will change for the better, so that they may have opportunity to show what they can do.

'In general, the present development of science in America is highly encouraging. Future progress will depend, not so much on the formation of influential scientific clubs as on our laboratories, our periodicals, our local societies and the policy adopted, as to patronage, by the government and our universities. Meteorology will especially advance whenever some one establishes a meteorological laboratory in connexion with some first-class university, giving it conveniences for experimentation on a large scale, furnishing it with an experimental physicist, a mathematical physicist, and several student fellowships, and allowing these abundant time to work out completely the first few problems that they may see fit to undertake.'

CHAPTER VII

The Weather Day by Day; How it may be Accurately Forecasted—Achievement in Prediction

The Facile Term 'Weather': what it Connotes.
'As Changeable as the Weather' represents the High-Water Mark of Erratic Humanity.
Mystery of Weather Causation regarded as Insoluble.
Cramping Influence of Old-Time Ideas concerning Weather.
All the World over, with a Few Exceptions, 'There's More Good Weather Than Bad.'
No Progress in Achievement in Official Circles: the Prevailing Tone there one of Despair.
In Every Other Science the Cry is 'Colours! Fifty Paces Forward!'
Meteorologists Blinded by the Brilliance of the Object they Worship.
How Meteorologists Give Themselves Away by their Frequent Confession of their Lack of Knowledge.

Robert H. Scott, in *Elementary Meteorology*	Sir Gabriel Stokes, F.R.S., Meteorological Office Records
Hon. R. Abercromby, in *Weather*	The Astronomer Royal in Nov. 1893
Chambers' Encyclopaedia, art. *Weather*	And others.

In the United States a Like Helplessness Exists.
No Further Monsoon Predictions in India.
Fallacy of Comparisons of the Moon's Changes as Affecting the Weather: those Comparisons have No Relation to Mr. Clements' Theories.
The Great Treasury in the United Kingdom of Observations and Records—a Monument of Painstaking and Unselfish Labour.
In the Meteorological Sphere 'the Eye of Prophecy Looks Backward.'
The Inefficacy of Present-Day Observations and their Necessary Failure.

What is always Left Out of Consideration.
The Moon's Varying Distance from the Earth.
The 'Pull' of the Moon on the Atmosphere: Tidal Air-Waves.
Professor Darwin's Comments on the Tide-generating Force of the Moon.
Mr. Christie's dictum: 'The Test of any Prediction is its Success or Otherwise.'
Tried by this Test Mr. Clements' Predictions Triumphantly Vindicated.
Weather Problems Solved by Application to Meteorology of the Law Prevailing in Other Directions in the Solar System.
Mr. Lecky on the Fixity of Natural Law as a Commonplace in the Human Mind To-day.
Doubts as to the Universality of the Principle; that which is Unfamiliar still regarded as Necessarily Wrong—even in some Scientific Circles.
Mr. Clements' Theory Stated in his Own Words.

1. *WHAT IS IT THAT MR. CLEMENTS HAS DONE?*

Adverse Weather Conditions Accountable for Eighty per Cent. of Agricultural Hindrances and Losses.
How Mr. Clements Began his Research: the Advice of Friends: 'Leave it alone.'
An Orthodox Beginning—Sun-Worship Included.
The Moon's Over-powering Influence in Weather Causation Accidentally Discerned and, for a long time, Resisted.
Present Accurate Prediction: Results only Reached after Many Trials and not a Few Disappointments.
A Lucid Description of the Actual Working of the Causation Phenomena.
The Clues at Last in Mr. Clements' Hands.
Formula Describing the Laws which Mr. Clements Found in Operation.
Secret Once Discovered Found to be Simple and Readily Understood.
Nature Herself the Greatest and most Trustworthy of all Weather Prophets.
Mr. Clements' Caution in Commencing his Predictions.
Forecasts in *Tinsley's Magazine* in 1890.
Detailed Particulars in Almanac for 1892, Reached a 93 Percentage of Accuracy.
Prediction of the Queen's Jubilee Weather, 1897.
Repetition on June 24, in Essex, of a Destructive Hailstorm, like unto a Similar Storm in Middlesex on June 23, 1764, the Period Covered by the Embracing Cycle of the Moon's Movements.

Coronation Weather, June 1902: Prediction and Verification.
A 'Trifling Divergence,' and an Explanation thereof.
Ascot Weather, 1902.
Five Months of Continuous Prediction.
Diagrammatic Presentment of Barometric Curve and Days of Rainfall.
Detailed Descriptions:
Air-Tidal Movements. Rainfall Prediction.
Easter Weather Predictions in 1898; Barometric Prediction and Verification for April.
Earthquakes in April, 1890–97.
Submission that the Clements Predictions are now Verified Facts on which Action should be Taken.
Appeal to Professor G. H. Darwin and Professor Sir Robert Ball.
Professor Darwin on the Degree of Accuracy in Tidal Prediction.
Comparison between Prediction and Actuality at Portsmouth.
Errors amounted to 177 in Time and in Height in Three Months; 381 in Time alone in Twelve Months.
Like Irregularities and Discrepancies for Aden.
Tidal Prediction, Notwithstanding Errors and Discrepancies, Based on a True Conception of the Phenomena.
Where Predictions are Fulfilled the Truth of the Theory on which they are Based is Guaranteed.
Sir Robert Ball on the Demonstration of the Correctness of the Nebular Theory.
Strength of the Demonstration Indicated by a Parallel in the Tossing of Coins.
'Even with No More than Nine Planets and the Sun,' each Turning on its Axis One Way, Demonstration Ensured.
Even the Contrary Turning of the Satellite of Neptune and the Inconformity of the Planes of the Moons of Uranus held to Prove the Nebular Theory.
Comparison between Tide Records and Clements Rainfall Prediction.
Comparison between the Nebular Hypothesis and the Clements Discoveries.
Clements Predictions far more Accurate than the Tides.

2. *WHAT IS IT THAT MR. CLEMENTS IS READY TO DO?*

Mr. Clements' Prodigality with his Painfully-Acquired Knowledge.
'One of the Merits of the Newly-discovered Law is that it Does Not Run Counter to any Vested Interests.'

IV. Forecasting:
Numerous Instances of Identical Weather Results with Similar Positions of Moon's Parallax, Declination, Phases, Apses, and Apsidal Differences, with Two Important Tables of Maxima and Minima Rainfall Results.

V. Examples of Barometrical Curves at Periods of Similar Lunar Attraction.

THE facile term 'weather,' lightly and glibly employed as though it were an easily-understood entity, represents, in reality, a vast complexity of seemingly insoluble phenomena. Within its scope are included the destructive storm—in the varied forms of typhoon, tornado, cyclone, hurricane, and cloudburst—the useful moderate wind and the gentle zephyr, the doldrums of the equatorial seas, the raging waters of the Roaring Forties, and the ice-cold wind-terrors of Cape Horn.

The term covers the phenomena of the rainless area of the Arabian peninsula and the torrent-swept sides of the Himalayas, with, as at Cherrapoonjee, nearly 500 inches of annual rainfall. Town fog, sea fog, and mountain mist, are among its manifestations. Bright sunshine and a clouded atmosphere are its more familiar aspects. The glories of sunrise and sunset, the 'light that never was on sea or land,' that light which conducts the awe-struck soul into the presence-chamber of the All-Glorious with a reverence no turmoil and no stain of earth can wholly prevent;—these are of its essence. Rain, hail, snow and ice,—the rain and ice in their many varied forms,—come within the wide range covered by the word, probably the most fecund word in all our language. To every class of the community the weather is an object of vital interest, from the farmer whose crops depend upon its manifestations being favourable to cultivation to the butterfly of fashion whose attendance at a garden party is helped by a favouring mood or hindered by an angry array of cloud. Its moods are multitudinous. Its changeableness, so far at least as the climate of the

United Kingdom is concerned, has become a synonym for fickleness. 'As changeable as the weather' represents the high-water mark of erratic humanity.

> 'Age cannot wither, nor custom stale,
> Its infinite variety.'

So it has come about that of all things in, on, or under, the earth, naught seems so elusive or so tantalizing as the secret of the weather; no task so utterly beyond man's power as an accounting for the weather day by day; while long-ahead prediction is considered to border on blasphemy. The mystery is of old time, and has been regarded from old time as insoluble. 'The wind bloweth where it listeth, and thou hearest the voice thereof, but knowest not whence it cometh and whither it goeth.' These words, used illustratively of the equally unseen action of the spirit of righteousness in the soul of man, have led some to think that the movements of the wind, the secrets of the changing weather, will never be revealed to man's curiosity,—that the words thus spoken, showing though they did, the non-scientific knowledge of the age in which they were uttered, were meant to be a warning against those who would scale the heights to snatch the Promethean fire; they were to remain a record and to be for ever a warning to presumptuous men against impious investigation. There are devout Christian folk who, if they were told that daily weather could be accurately foretold three years ahead, would feel that, even if it could be done, it would be contrary to the spirit of God to do it, and they would hesitate to make use of such knowledge.

In spite of its myriad manifestations, and notwithstanding the cramping influence of a scriptural saying which was intended simply to illustrate an unseen but nevertheless potent state of mind, and not to utter the last word of science on the winds, there are, probably, few

people who, if pressed, would not agree that all the complexity and apparent waywardness of the phenomena denominated weather, are a measure of man's ignorance and not an example of any want of order in Nature. Behind all this fleeting and often seemingly contradictory and always puzzling phenomena, it would be generally conceded there must be laws which, once understood, would make the seeming whirl of contradictions, oft in wandering mazes lost, anon exhibited as a scourge of terrible effect, still more often the personification of harmony, simplicity, and beneficence.[1] There must surely somewhere be a single controlling influence which, once understood, would account for all the apparent disharmonies around us, command admiration, and make the difficult paths easy. 'It could not be that, alone among the operations of Nature, there was not a simple law whereby all the apparently confusing operations of the weather could be brought into harmony and simplicity. Such reasoning is wise. The order, the regularity, the simplicity, the co-ordination of moving bodies to compliance with one general law, which Kepler and Newton evolved from seeming complexities in the movements of members of the solar system, undoubtedly mark the phenomena which we call weather. Once discovered all that now puzzles and disturbs, nay, more, which in the form of hurricane and earthquake, and the belching forth of fiery matter, terrifies mankind, will be found easy

[1] On the whole, in most parts of the world—such regions as Cherrapoonjee, with 464 inches of rain per annum, excepted—there is more good weather than bad. When crossing from New York in 1896 in the American steamer *St. Louis*, the chief officer of that ship showed that he was of the opinion expressed. We were passing south of Ireland. I suggested that he often experienced bad weather there. He did not think so, he said. 'Well,' I asked, 'what is the weather here like?' He pondered a moment, and then replied: 'I reckon it is here as it is in most other places—there's more good weather than bad.' An interesting scientific fact, not without a moral!

of explanation; even more than that, will prove consoling to heart and mind. For here, as in the other regions of Nature, knowledge will be accompanied by the handmaidens of prevision and precaution.

As matters meteorological and astronomical stand at the present moment such a position would appear to be unattainable. Neither in the vaulted dome of the astronomer's observatory, nor in the office of the meteorological department which, by the telegraph wire, is hourly in touch with a multitude of stations from one mile to thousands of miles distant, is there even a hint that so much as a single step forward into the domain of the unknown workings of the weather may be taken with confidence. Indeed, the prevailing tone in official weather-circles is one of despair. There the assertion is made that such a step may not yet be taken: it is almost hinted at that it may never be taken. Why is it that, in a matter of vital importance to the human race in a thousand forms, there should be naught for the eager inquirer but a confession of incompetence—always a confession of incompetence? In every other region of knowledge, even astronomical knowledge, there is no bound placed, or even imagined, to the taking of not one step, but many steps forward. In everything else that incident of the American Civil War—'Colours! fifty paces forward!' is being incessantly repeated. Only in meteorology does 'marking time' suffice. Eager students in other branches of knowledge press forward into new and unknown domains of Nature's vast undiscovered realms and are loudly and generously acclaimed when they bring back the spoil of unwearied observation or clear up baffling mysteries by discerning and revealing the true working of a hitherto misunderstood law. But, in regard to the weather, none among all the ardent and intrepid soldiers of science appear to be ready to readjust their position; having failed all

along the line of existing ideas in their search for the causation of weather phenomena, few will attack new sources of probability, or, what is equally important, pick up discarded theories and re-examine them from a fresh standpoint. On the contrary, astronomers and meteorologists together confess their impotence, and some amongst them even seem to count it a merit that they are alike ignorant and impotent. There is only one explanation for so puzzling a matter, but that is all-sufficing; each meteorologist has gazed so long at the sun as the source and controller of all weather phenomena that he has become blinded by the brilliance of the knowledge-bearing rays which have little to teach him on this subject. The hypnotism is as complete as it is lamentable. Consequently, instead of advancing kuowledge, and in place of inspiring respect from the multitude by the accuracy (and, if accurate, the beneficence) of their teachings, they themselves actually provide the weapons by which they are overcome, and by which they are held captives to contemptuous treatment and to scornfulness. No citizen considers himself so low in the scale of criticism that he feels it would be unseemly for him to jeer at the weather-prophet—of Victoria Street and elsewhere.

Assuredly there is no branch of human knowledge which is so frequently made an object of ridicule and occasion for derisive scepticism as that which relates to the forecasting of the weather. Unfortunately, as I have already remarked, the forecasters themselves have been mainly to blame for this almost universal attitude of mind. Their mistakes have been grotesque and numerous. At length the 'weather-wise' (or 'otherwise'), the meteorologists who make predictions, have, with profound resignation, accepted the position of inferiority which they are held to occupy, and are willing to sit contentedly under the ill-concealed contempt which has become widely prevalent; they seem to mind it so little that, for their

own part, they are not slow to furnish evidence of their own lack of knowledge. Thus Mr. Scott, M.A., F.R.S., the late Director of the Meteorological Department, London, on page 4 of his work on *Elementary Meteorology*, says:

'We cannot claim for the study of the weather that it has as yet made much practical progress in enabling us to foresee or forecast its course for more than a few hours, and we must admit that it has made next to no progress at all in gaining an insight into the agencies which are at work in producing the various phases of weather.'

In the Hon. Ralph Abercomby's treatise on *Weather*, page 430, the author says:

'We can now readily understand that forecasting depends neither on any theory nor on any calculation. The whole science from beginning to end rests solely on observation. In like manner we see that no averages nor mean values are of any avail in forecasting weather.'

On page 433 he also states that—

'From eight to twelve hours seems to be the furthest time for which forecasts can be issued in advance.'

In the article 'Weather,' in *Chambers' Encyclopædia*, it is stated that—

'the changes of the moon were long, and in many minds are still, regarded as supplying the elements of prediction. In order to test the real value of the moon's changes on the weather the Greenwich Observations of fifty years were carefully examined, and it was found that the number of instances in which the weather was in accordance with the prognostication was one instance less than those in which the weather was different. The theory of the moon's changes on the coming weather is thus proved to be a complete delusion. The truth is that no prediction of the weather can be made in the British Islands at least for more than three, or perhaps only two, days beforehand. All observation goes to prove that predictions based on solar or other astronomical causes

are without foundation, and that averages based on terrestrial observations are the only guides we have in this matter.'

Sir G. Gabriel Stokes, F.R.S., M.P., wrote to Mr. Clements on November 14, 1884, as follows, viz.:

'The notion that the weather is related to the time of day at which the moon's principal changes of phase occur is now a thing pretty well exploded.[1] Nor does it seem that the moon's changes of any kind exercise a material influence on the weather.'

The Meteorological Office stated at the end of 1901 that—

'the time is not even in sight when we can predict the weather locally for even a few days, and this office has been working at the problem for over thirty years. Twenty-four hours ahead is the utmost of safe predictions, which we deduce not from phases of the moon but from the barometer, the winds, the strength and rapidity of air-currents, and the state of the sea.'

Only a few days previously the same Office had said:

'No one in his senses can believe in the moon's influence upon the weather. The fact that storms move over the surface of the earth is sufficient to show that if the change of weather suits the moon in Ireland it must fail to suit it in England.'

Further, the Astronomer-Royal wrote from the Royal Observatory, Greenwich, on November 18, 1893, as follows:

'There can be no question but that the successful prediction of weather would be in many ways of great advantage. In

[1] A statement with which no one can be more heartily in accord than are Mr. Clements and the present writer. Such empiricism as is here condemned has no place in the well-ordered and scientifically-conducted inquiries and investigations of Mr. Clements.

tropical regions there may be a possibility of doing something, but in a country like England, bordering on the Atlantic Ocean, it is found impossible with the best information to hand to make reliable forecasts for long in advance, usually not more than a day or two, the changes approaching from the westward come on so rapidly. To attempt in any way to predict for long periods in advance—for months or for a following year—is useless.' Mr. Clements professes to base all his predictions on the positions and aspects of the moon. Many men have tried long before Mr. Clements' time to determine whether meteorological conditions in any way depended on the moon, but all have successively failed. The influence of the moon is of the smallest. It is doubtful whether it is really measurable. The sun is the real disturber of the weather, his action on the atmosphere, combined with the revolution of the earth on its axis, producing all the changes we experience. It is the influence of solar heat. People say, But, the moon causes the tides. Quite so. But this is a matter of attraction, a different thing altogether. But, after all, the test of any prediction is in its success or otherwise.'

In a recent volume of *Whitaker's Almanac*, page 78, it is stated that—

'Meteorology is purely a science of observation, and, from want of knowledge concerning the laws which govern the fluctuations of the weather, failures in the forecasts must happen, and no reason can be given why certain states of the atmosphere which previous observation would lead us to believe should be stable, suddenly break up without any apparent warning. The idea that the weather is dependent on the moon's phases still finds favour with the vulgar, although any appreciable connexion has been repeatedly disproved.'[1]

As for India, where co-ordination of observation, so far as this is the result of mere administration, has

[1] The reason for the failure described in this citation lies in the circumstance that parallel days or months are compared with the respective phases of the moon and with the days or months without allowing for the perturbations of the moon. The failure hitherto has lain not in the moon but elsewhere.

attained to heights hitherto unreached elsewhere, it was announced from Simla, in June 1902, that no further monsoon predictions would be issued.

In the United States the same helplessness exists. A few years ago, Professor Moore, chief of the Weather Bureau, stated that, in his opinion, it was impossible, upon any principles of physics [1] or empiric rules of meteorology, to predict the weather for more than a few days. Much of the failure arises from the comparing of things which are not comparable.

It is fallacious to compare, as is frequently done, the wet or drought of June, July, or any other month of one year, with the corresponding month of another. No one asserts that fact so emphatically as Mr. Clements. If the weather were controlled solely by the sun the comparison could be made. The fact is the concurrence of a weather-producing period of about 353 days forbids such a comparison, and, as we progress year by year, similar weather is thrown back yearly by nearly twelve days; it is only after a lapse of thirty-one, or, more preferably, sixty-two, years that the months of the year would correspond. But as, for about five years, the weather at any given place gradually extends about three hundred miles to the north and for nearly the same

[1] '. . . it was impossible, upon any principle of physics,' etc. Why, it may be asked, should any one assume that the last word on meteorological science has been spoken, until, in this particular realm of knowledge, every region has been explored, every phase of a multitude of complex movements, actions, and interactions, have been properly co-ordinated and their full value quantitatively, as well as in relation to each other, ascertained? No department in science is a completed investigation. No department in science is so far from attaining such a position as is meteorology. It is occasion for painful regret that, of all places in the world and from any men, such a counsel of despair should have emanated from the Weather Bureau of the United States, and from such eminent observers as Chief Willis L. Moore, Professor Cleveland Abbe, and their coadjutors.

time the similar weather recedes as far south, it is evident that, in most cases, no useful and satisfactory comparison can be made between the wet or drought of any one July and of any other. In making the comparison months are compared with one another that are non-comparable so far as the cause producing weather is concerned. No month escapes its turn of being wet or dry as, in the efflux of time, it comes under the similar natural weather-producing agencies.

I make no protest against the common judgment of mankind. The weather-prophets of the past and of the present, mere guessers at their best, have themselves, as we have seen, forged the weapons with which they are assailed. With such materials as they chose to use it must be recorded that they have done as well as any human beings could do, and far better than might, in the circumstances, be expected. To them the world owes the great treasure of a mass of close and accurate observation and records of the daily temperature, diurnal rise and fall of the barometer, the number of hours of sunshine on each day, the prevalence or absence of clouds from morn till eve, the extent and time of rainfall during each twenty-four hours. Every one of these records is essential to accurate weather-forecast. In providing them the meteorologists of to-day have justified themselves as reporters, and, by what they have done, have placed future ages under a deep debt of gratitude. With the adoption of the Clements system the records obtain a value which, at the present moment, and unused, is inconceivable. Mr. Clements goes behind all the observations to study and record the causes of which those observations are the outcome. Failing accessibility to the records of the past weather day by day he could do less than he now does in accurate forecasting. Let his system be fully adopted, and the value of every existing observation of barometer and thermometer, every detail

of sunshine and cloud, every record of rainfall and wind direction and force, acquire value many hundredfold beyond what they now possess. For, in this field, truly the eye of prophecy looks backward; the prophecy made to-day and to-morrow is simply the record of past days reproduced under like conditions to those previously existing.

Mr. Clements finds that certain combinations of the sun and moon produce in the atmosphere of the earth certain results. Given those combinations, and they are ever being repeated in harmonious sequence, the results are always identical. Mr. Clements does not proceed to 'reason down' from the far-away combinations, and say,—In England, or indeed in any other country in the world, such and such atmospheric effects will follow, and in a particular part of the country there will be so many hours of sunshine, or so many fractions of an inch of rain, or again, the wind from a particular quarter and of a precise force and volume, because I have seen such and such a conjunction of sun, moon, and earth.

This is what the meteorologists now do. They do not reason from data afforded by a study of the primary causes; they tell us of the immediate future from what they see for themselves or learn of that which is actually observed in various localities with which they are in communication. They argue: From this and that condition at Stornoway (or the Faroe Islands, or anywhere else in that region) like conditions, if the wind blow from the northwards, at such and such an hour will be manifested in London. Likewise a southerly wind with a little west in it will take to the metropolis, in so many hours, more or less, the weather which, at a particular moment, prevails in the Bay of Biscay. Sometimes they are right; much more frequently they are wrong. The reason why they are wrong is not because they do not

observe accurately and reason lucidly on what is before them, but because they act as if the heavenly bodies which control the atmosphere, and which are every moment exercising an influence, always occupied the same position towards one another, and therefore might be left out of their reckoning. Were that the case, were the conditions always constant, their percentages of accuracy would be reasonably large, their forecasts might indeed become absolutely accurate. But they leave the power and varying positions of the two great bodies, the moon and the sun (particularly the perturbations and 'pulling' force of the moon), which together hold the world, and especially the world's atmosphere, in their thrall, to do with it as they will (but always according to law, always in the same way and to the same extent, all other things being equal)—they leave all these things out of their consideration. They do this on a plea which would hardly be believable as coming from men of science; an inquiry, they say, has shown that the weather in any part of the world is not the same at full moon or at new moon, at half moon or at the gibbous phase of the moon, in a particular month as it was at the same phase in the preceding month. Q. E. D. No one can deny the correctness of the observation. Changing weather, as they see it, does not correspond with the phases of the moon as they see them. Nor can one deny the shallowness of the researches which make the statement quite accurate, as accurate indeed as it is beside the mark. A little consideration as to the factors in the problems should have brought to mind the important circumstance, among others, that the distance of the moon from the earth varies month by month, even day by day, and that the attractive influence of the moon upon the earth's atmosphere must change also. Mr. Clements, in 1893, calculated the respective distances of the new moon from the earth in the preceding year. This is what he found:

Month	Distance
January	234,000 miles
February	227,000 „
March	223,000 „
April	224,000 „
May	227,000 „
June	232,000 „
July	233,000 „
August	243,000 „
September	245,000 „
October	249,000 „
November	249,000 „
December	243,000 „

The respective distances varied from 223,000 miles in March to 249,000 in October and November, or a difference between those months of 26,000 miles. (In like manner there is a difference in the sun's distance from the earth of two millions of miles; at perigee the distance is 90,830,000 miles, at apogee it is 92,925,000 miles.)

As the attractive pull of the moon upon the earth's atmosphere varies inversely as the square of the distance, it is evident that the tidal power of the moon could not be the same at each new moon in 1892; the weather consequently could not be the same. It was unreasonable to expect it to be so, especially as the declinations of the moon at the times of new moon were all different. Proceeding from January 1892, the declinations were respectively for each month:—January 22°43′ S.; February, 12°46′ S.; March, 0°12′ N.; April, 12°49′ N.; May, 22°43′ N.; June, 27°11′ N.; July, 24°40′ N.; August, 16°12′ N.; September, 3°42′ N.; October, 9°45′ S.; November, 21°21′ S.; and December, 27°24′ S; and, of course, the declinations of the sun were also different. Further, the angular distances of the moon and sun for Greenwich (or any other place) were not alike for any two new moons during the year, and, once more be it said, the weather could not be the same.

It will be seen that between the most distant point of the moon from, and the nearest approach to, the earth so much as nearly one-ninth of the total distance is involved. In this connexion Professor Darwin's remarks on the force of the moon's attraction as affected by its distance from the earth are instructive. Had such fundamental truths as are enunciated by him been in the minds of the committee of learned astronomers who took fifty years' records of rainfall, and fifty years of new moon and full moon, and compared one set of observations with the other set without taking into consideration the perturbations of the moon, they most assuredly would not have stated that the moon had nothing to do with the causation of the weather. These are Professor Darwin's observations:

'It has been shown in Chapter v. that the intensity of tide-generating force varies as the inverse cube of the distance between the moon and the earth, so that if the moon's distance were reduced successively to ½, ⅓, ¼ of its original distance, the force and the tide generated by it would be multiplied 8, 27, 64, times. But the efficiency of tidal friction increases far more rapidly than this, because not only is the tide itself augmented, but also the attraction of the moon. In order to see how these two factors will co-operate, let us begin by supposing that the height of the tide remains unaffected by the approach or retrogression of the moon. Then the same line of argument which led to the conclusion that the tide-generating force varies inversely as the cube of the distance, shows that the action of the moon on protuberances of definite magnitude must also vary inversely as the cube of the distance. But the height of the tide is not in fact a fixed quantity, but varies inversely as the cube of the distance, so that when account is taken both of the augmentation of the tide and of the increased attraction of the moon, it follows that the tidal retardation of the earth's rotation must vary as the inverse sixth power of the distance. Now since the sixth power of 2 is 64, the lunar tidal friction, with the moon at half her present distance, would be sixty-four times as efficient as at present. Similarly, if her distance were diminished to

a third and a quarter of what it is, the tidal friction would act with 729 and 4,096 times its present strength. Thus, although the action may be insensibly slow now, it must have gone on with much greater rapidity when the moon was nearer to us.' (*Tides*, pp. 246, 247.)

Not only do meteorologists, who may or may not be astronomers, leave such material considerations out of their purview, but, it may be insisted upon, in view of the evidence quoted on a previous page, that even among astronomers the Astronomer-Royal of England, in observations already quoted (p. 263), does not take into account what certainly seem important factors in such a problem, factors which should be recognised at the Greenwich Observatory if anywhere in the world. However, Mr. Christie candidly and commendably says:—'After all, the test of any prediction is its success or otherwise.' In the course of a few pages the reader may see one particular prediction indicated in which the chances of success, unless it were based on fundamental and irrevocable law, were as

1,000,000,000,000,000,000,000,000,000,000,000,
000,000 to unity.

This success, and like successes, which will be found on record in this chapter, the testing of which is demanded of all who are sceptical as to the truths herein enunciated, should make of the Astronomer-Royal in England the stoutest of protagonists of the Clements system. That system is merely an application to weather problems of the same class of reasonings as those which led to the discoveries of Kepler and Newton; the reasonings concerning the solar system, in a word, are applied to meteorological conditions. They are the reasonings, too, of the late Sir John Herschel. In his work on Meteorology Sir John exhibits great insight into, and knowledge of, the laws of meteorology, and although he could not predict the weather he enunciated one principle which Mr.

Clements has always found to be accurate. He laid it down as an axiom that the weather would never be successfully predicted until the movements of air pressure could be satisfactorily foretold. This is indeed the foundation-principle of all that Mr. Clements has done with a success in accuracy of prediction which would be phenomenal, would be almost beyond human credence, were he not guided wholly by natural law.

Mr. Clements has hitherto found that a rational statement, with abundance of proof placing that statement beyond peradventure, is not sufficient to command assent. It may be true, as Mr. Lecky says:

> 'The sense of the fixity of natural law is now so deeply implanted in the minds of men that no truly educated person, whatever may be his religious opinions, seriously believes that all the more startling phenomena around him, storms, earthquakes, etc., are the results of isolated acts of supernatural power, and are intended to affect some human interest.'

Correct as this is, in a general sense, it may be equally true that men are too prone to think that only to be natural law which they themselves already know. The extent of their knowledge marks the boundary of that which is to be known. Even in these days of culture and enlightenment and of so-called emancipation of the mind from prejudice, there are those, in the most learned of the professions as well as those in no profession, who do not want to inquire too closely into the truth of that which runs counter to their preconceived views or presently held opinions. We all are too ready to assume that what we ourselves, or our particular circle, know of a particular subject is all, or nearly all, that there is to be known; or, put in another way, all that need be known. We resent any one coming in with new views which have never occurred to ourselves. The mere doing of this we regard as an affront to our intelligence. The

promulgator of a newly discovered natural law, if that law run counter to what passes current as an explanation of phenomena,—even though that explanation be admitted to be insufficient in the twentieth century of the Christian era as in the first century,—finds men's minds closed not merely to the acceptance, but too often even to the consideration, of his conclusions.

Whether the abundant evidence which this book contains concerning the accurate results following from the application of the newly-discovered law as to the production and control of weather-conditions will avail to change the too frequent experience of to-day remains to be seen. Any new assertion, because it deals with that which is unfamiliar, it may be again said, is only too readily pooh-poohed without adequate examination. So much advantage in the way of additional security to human life and in the form of preventible loss of property would accrue from the acceptance and full use of Mr. Clements' new laws as to the causation of meteorological phenomena that, possibly, a welcome change may be noted after this work has passed into circulation.

In brief outline Mr. Clements' theory may be thus stated in his own words:

'The movements of the air are controlled by the moon and the sun jointly, but, by comparing the air-pressures for a number of days at or near the same time of the year, I am able to eliminate the sun's influence and to produce my curve, showing air-pressure for a considerable period ahead solely upon the moon's movements.

'With the necessary weather-records for past years in my possession for examination, the same calculations that I use for predicting a barometric curve for London could be used for any spot on the earth's surface.

'Had I an adequate (but not necessarily numerous) staff of computators in London, and the co-operation of meteor-

ologists throughout the world, successful prediction of the movements of the air and the resultant weather could be made for every country and every district thereof. Further, people of various countries could be trained to do the needful work for their own countries respectively.

'Drought and excessive rainfall, cold and heat, famines, earthquakes, volcanic eruptions, in a word all meteorological phenomena, could be satisfactorily predicted. With a knowledge as to the daily character of future weather the yield of agricultural produce all over the world could be very materially increased and the conditions of human life greatly ameliorated.

'All these things could be secured by the introduction and working in every civilised country of my system of forecasting the weather.'

THE MOON AS HEAT DISTRIBUTOR

There has been no appreciable increase or decrease of the sun's heat or light for thousands of years.

The solar heat and light are radiated into space in all directions.

The earth intercepts only $\frac{1}{2,200,000,000}$th part of the sun's heat and light.

The amount of solar heat radiated annually to every part of the earth's surface is constant except to the extent by which it is cut off by clouds.

As we have been enabled to predict the amount of cloud daily at any given place (say London) by means of the moon's motions, it follows that the formation of clouds and the quantity of heat received daily at any given place are affected by lunar action. With much cloud in summer the weather will be cool, and with little cloud it will be warm. The moon is the great distributor of clouds and therefore is largely a controller of solar heat.—H.C.

THE MOON AS WIND-PRODUCER

In Ganot's *Physics* it is stated, page 809, that 'winds are produced by a disturbance of equilibrium in some part of the atmosphere; a disturbance always resulting from a difference in temperature between adjacent countries.'

In Deschanel's *Natural Philosophy*, Part II., Heat, page 499, we find the following statement, viz.: 'When two neighbouring regions are at differing temperatures a current of air flows from the warmer to the cooler in the upper strata of the atmosphere; and in the lower strata a current flows from the colder to the warmer.'

In Scott's *Elementary Meteorology*, page 275, the following statement may be found: 'The winds of the temperate zone and of the higher latitudes seem to be regulated by the distribution of pressure, and this, as we have already seen, seems to depend on the distribution of temperature.'

Professor Ferrel states that 'the primary cause of the atmospheric motions is the unequal distribution of the tem-

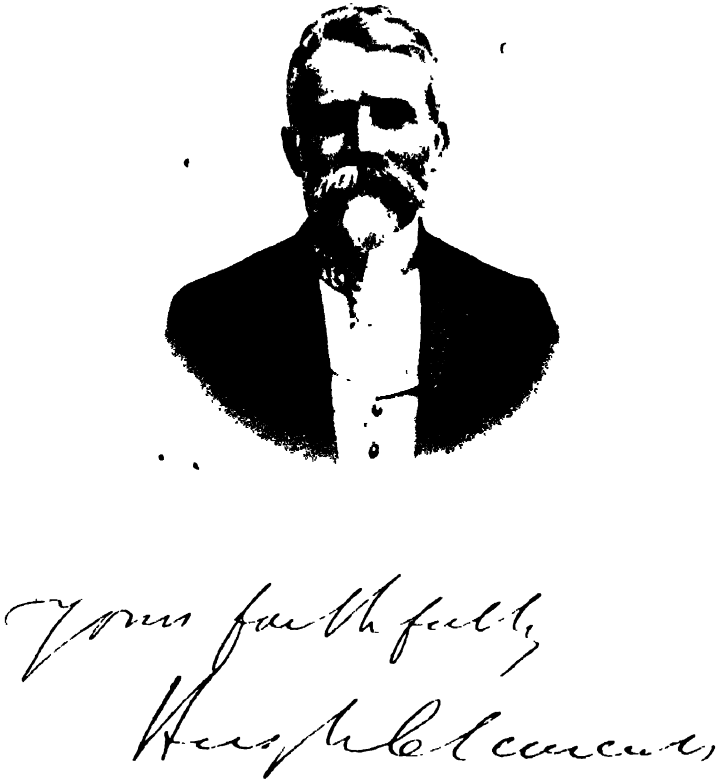
perature on the earth's surface produced by solar heat, and if temperature were everywhere the same the atmosphere would be at rest.'

Von Siemens states that 'the maxima and minima of the air-pressure are the result of temperature and the velocity of the air-currents in the upper layers of the atmosphere'; and he further states 'that the disturbances of the atmosphere are brought about by the super-heating, by the solar radiation of the air layers lying next the ground, and by the unsymmetrical cooling of the upper layers through radiation and through the damming up of moving air-masses caused by obstacles to their progress.'

Notwithstanding dicta so strongly stated as the above, it remains, scientifically, the fact that the moon is the prime producer of winds, and that temperature has no great effect.

The storms of April 6 and May 3, 1895, occurred at the time of the moon's perigee, as well as those of December 15, January 13 and February 11. The storms of January 31 and March 28 occurred about five or six days after the time of apogee, and the strong wind of January 5 and February 3 took place five or six days before, and those of December 22, February 16 and April 14 seven or eight days after the time of perigee. Finally the great and terrific storms of December 29 and March 24 last, when the pressure on the square foot was 28 and 36 lbs. respectively on the square inch, occurred at the time of apogee.

As every storm that has been recorded can be explained, and as storms have been and can be successfully predicted on the basis of the moon's motions, it is erroneous to say that heat is the cause, as the moon does not warm the earth's atmosphere in the slightest degree, and it is idle to say, when we have predicted storms as stated above, in accordance with the moon's position and motions, that the moon has no appreciable influence on the weather. Surely a pressure of 28 lbs. and even 36 lbs. on the square inch caused by lunar influence is somewhat appreciable. The storms of the winter of 1894, all predicted, did immense damage by sea and land, and the storm of March 24, 1895, simply devastated the East of England, and yet, according to orthodox opinion, the moon has no effect on wind or weather.—H.C.



[From a Photograph by Miss Annie A. Smith.]

[To face Page 277.

1. What is it that Mr. Clements has done?

2. What is it that he is ready to do?

A life-long student of the various sciences and arts, twenty-three years ago, then already an authority on agriculture, the author of two books on practical farming and chemistry, and intimately connected, as a contributor, with the leading agricultural newspapers, the agricultural distress which was then peculiarly acute in England especially attracted the attention of Mr. Clements. Of all the hindrances to successful farming agricultural experts ascribe eighty per cent. to adverse weather and only twenty per cent. to all other causes. It may be remembered that a series of very wet years in this country culminated in 1879 and 1880. Wrought upon by what he saw and heard Mr. Clements determined to attempt the solution of the weather problem. His own view was that if farmers knew what the weather conditions of a particular season were likely to be they would arrange their operations accordingly, sow that which the predicted weather favoured, and avoid those products which it would not favour. The task was entered upon with his accustomed energy. That great agriculturist, Sir J. B. Lawes, Bart., was one of the first to whom Mr. Clements mentioned his project. 'Leave it alone,' he said. 'I have tried for years and have failed. Whatever you do, don't place any dependence upon the moon. The moon has nothing to do with the weather.' Admiral Sir George Nares gave like counsel, but nevertheless remained a staunch friend of the earnest seeker after knowledge; indeed, had it not been for the series of *Nautical Almanacs* at the Admiralty, which Sir George placed at Mr. Clements' service, that gentleman would not have achieved the great success which this book records.

Meteorologists, journalists, indeed every one consulted, warned the young student of the folly of his undertaking. Sir John Lawes, with others, however, remained friendly. Sir John placed at Mr. Clements' service all his weather-records, with the result that, from some weather-accounts for a part of the fifteenth century Mr. Clements found one of the chief factors which he was seeking.

At first Mr. Clements was very orthodox in his researches. Like the rest of uninformed mankind he scorned the moon's influence, and regarded anything it might do as of little or no concern. He was impressed with the sun-spot speculations—as the consequence of the then recent terrible famine in India, with its life-loss of six millions, at that period a fashionable topic of study. The causation of the solar prominences specially interested him, and a long time was devoted by him to the estimate of the power exerted by the planets singly and in unison on the vaporous surroundings of the sun, and, secondarily, upon the earth's atmosphere. The effect of those studies will already have been seen in the chapter on Sun-spots. What led to the planets being abandoned as earth weather-controllers was a recognition of the fact that, when all of them were in line and were each pulling at the earth to its utmost capacity, the combined attractive force would be less than one-hundredth of that exerted by the moon.

The dictum of the Committee of Weather-Experts at Greenwich [1] was enough to discourage any one, who entertained the least respect for scientific authority, from believing that any weather-reliance could be placed in the moon. Sitting in judgment upon the suggestion that the moon controlled the earth's weather, the committee took the records of rainfall for fifty years and summoned the moon as witness in its own behalf to testify as to what it

[1] See p. 262, *ante*.

had to do with terrestrial storm and sunshine. Unhappily the moon replied in a language which, learned though they were, the committee-men did not understand; and, as even Royal Commissioners have been known to do, they reported against the facts because they did not rightly appreciate what was actually before them. They declared that they found, from fifty years' records, the weather did not conform to any cyclic repetition of the phasial, the apsidal, or the nodal, movements of the moon; therefore, the moon had no perceptible effect upon the weather. They might as well have said that a body acted upon by three forces should be in three different positions at one and the same moment. It should be in the position where Force No. 1 sent it, in the place where Force No. 2 pushed it, and also in the spot where Force No. 3 drove it, instead of in one position—the resultant position of the combined three forces. That the weather similarly does not follow each of the three lunar movements separately, but is the resultant outcome of all these forces combined does not seem to have occurred to them.

Again and again, finding that his various researches only led him into blind alleys from which, with empty hands, he had to return to the main thoroughfare once again to search for a way out, Mr. Clements collected from the *Nautical Almanacs* the times of new and full moons from 1767 to 1883—not exactly to play with, but certainly without any definite idea as to whether he would gain much from them. The respective times he had collected he proceeded to collate in tabular form, and then endeavoured to find cycles so as to ascertain what, if anything, the cycles, did they exist, would do for him. More by accident than from design he compared two periods at intervals of sixty-two years, and found the phases of the moon took place almost exactly at the same time of the day, but four days later in the month.

He soon afterwards found out that this was always the case. He thought he had at last found the philosopher's stone which was to resolve all his doubts and clear up each of his difficulties. It appeared for a time that he had discovered a great cycle. He was, however, soon disappointed; but this disappointment led him forward another step. He took thirty-one years—half of sixty-two—and found that at intervals of thirty-one years the full moon took place at the same time of the day two days later in the month, and *vice versa*. Still there was no solution, but a distinct sense of hopefulness was engendered, that the right track had been struck. Not being able to get anything satisfactory out of the phases of the moon, he turned his attention to the apogee and perigee of the moon, and he found these also, like the phases, recurred at the same time every sixty-two and thirty-one years. This was to him a very interesting and critical position. It was the turning-point in the inquiry. The paramount question now was, could he so combine the phasial and apsidal movements as to obtain some index to the weather? After trial he found that the only way in which he could combine these two lunar factors was by taking the difference in time between the times of new and full moon and the times of apogee and perigee. He tabulated these differences month by month from 1833 (the first year for which the times for apogee and perigee were given in the *Nautical Almanac*); and, on comparison, he found that these differences were exactly similar at sixty-two and thirty-one years' intervals, and also at eighteen and thirteen years (making thirty-one), at their difference, five years. Doubling that difference, ten years, and doubling again, twenty years, they were still approximately similar. Previous to 1833 he calculated the times of apogee and perigee, and on comparing the weather for similar aspidal differences he found a very marked similarity.

Later, Mr. Clements explained his discovery in more popular terms.

'In order,' he said, 'to understand the incidence of weather, it is necessary to indicate the agencies that control or modify its production. The two great prime motors causing weather are the moon and the sun. The sun's influence may be taken as a constant, the vagaries of the weather being due to the rapidly changing, and the various complicated, movements of the moon. The sun, in his extremely gradual movement from the zenith of the tropic of Capricorn to that of the tropic of Cancer and back again, from the time of Christmas to Christmas again, pulls the atmosphere in the same way, and emits the same amount of heat. So that the pulling force on our atmosphere and the heating effect on any part of the earth's surface is exactly the same on any given date of any given month year after year for centuries, the variations in attractive force and in daily temperature being due to the comparatively rapid movements of the moon in her approach to and recession from the sun, not only as indicated by right ascension and declination, but also in absolute distance from the earth and sun. The sun might be termed the *hour-hand* of meteorology, while the moon may be likened to the *minute-hand* in her north and south and east and west movements, and to the *second-hand* in her quick apsidal motions.

'Due to the practically constant distance of the sun from the earth, and his very slow daily movements in declination, his influence upon the weather is so comparatively equal and constant, that it may be neglected, and the moon's motions alone considered in the estimation of weather-changes.

'The moon has three main movements going on simultaneously. There is a complete revolution of the line of apsides in 8·85 years, of the nodes in 18·6 years, and of the tides in sixty-two years—seven apsidal revolutions being equal to one tidal, and ten nodal revolutions being equivalent to three tidal, positions. So that every 186 years the apsidal, nodal, and tidal, positions of the moon are similar; the result being that at intervals of 186 years there is a very considerable agreement in the weather; *e.g.*, the years 1692 and 1693 were the exact meteorological counterpart of 1878 and 1879, and the years before and after these dates were very similar.

'As we have not detailed daily information of the weather 186 years ago, it is necessary, if possible, to obtain a shorter interval. We cannot make use of the sixty-two years' interval, because it is only occasionally in years at that interval that the moon is in similar nodal positions, and the same holds good with a thirty-one years' interval, and, in fact, with any other interval of years excepting 186. Indeed, it is necessary to discover for the year whose weather we wish to forecast, some former year when the apsidal, nodal, and tidal, coefficients were similar.

'The apsidal and tidal elements may be combined by taking the difference between the times of new and full moon and the times of apogee and perigee, and the question is now solved by finding a year when the nodal element was similar. In this way the corresponding year, so far as these three elements are concerned, may be found at intervals of one year and upwards without limit,—accuracy of similarity of position of the moon relative to the earth and sun being the main consideration.'

The clues, at last, were in Mr. Clements' hands. Incomplete as they palpably were, they created confidence in his mind that he was on the right track. Here were no magical processes, no guessing at the significance of mackerel clouds on wind-causation, nothing of an *ad captandum* or thaumaturgical character, but sound, simple, irrefragable, scientific, principles. Even more in the material universe than in the spiritual world is it the fact that as it was in the beginning is now and ever shall be. Mr. Clements had discovered in regard to the world's weather the application of certain laws which are found to work 'with no variation or shadow that is made by turning' in all other realms of Nature. Those laws find description in this formula:

Nature continually repeats her phenomena.

In like conditions exactly similar results follow, other things being equal.

The Moon, according to the position it occupies in respect to the earth, repeats the influence it exerted on the earth's atmosphere, oceans, and solid crust, when it was previously in a like position; further, it exercises a maximum influence when at a particular angle and in line, or at a tangent, with the sun.

All the details of atmospheric influences repeat themselves at intervals under like conditions of these bodies, and with like conjunctions..

No need exists for guessing as to what, in such circumstances, will happen. That which has been is that which will be. Nature's own record, made on a preceding day, may be transcribed for to-morrow's use.

Thus, it follows that barometric pressure, increase or diminution of clouds, much or little sunshine, an overplus, an average, or a scanty, supply of rain, earthquake-shocks, volcanic eruptions, will all occur in time to come as they did in times past, so long as, in the case of shocks and eruptions, weak spots remain in the earth's crust.

For, it is further demonstrated, that the moon and the sun together control the atmosphere and produce its changes in the proportion of two parts exerted by the moon and one part by the sun.

Beyond all peradventure, in the movements and in the attractive power exerted by the solar and lunar bodies lies the secret of weather phenomena, a secret which, in Nature's customary fashion, when once she is rightly understood, is no secret at all. On the contrary, she herself becomes the greatest and most trustworthy of weather-prophets in that all she demands from mankind is an accurate record of what she really does day by day. When, once more, the moon appears in the position she occupies to-day, with the sun in like position, the same phenomena as that which is passing under our eyes will be reproduced. If the sun should occupy a different position, some allowance in regard to the exact repetition of phenomena must be made.

It all sounds very simple. That simplicity is one of the strongest proofs in its favour. What measure of truth have nineteen years of study and examination established?

'I did not commence,' says Mr. Clements, 'to predict the general character of the weather for several years after I felt certain that the conditions which prevailed with respect to the past would prevail in the future. I did make some predictions from time to time, and if a certain prediction depending upon a certain law remained unfulfilled, I abandoned that law; but if I found that had I exercised more care, or had I possessed more knowledge, my forecasts would have been different and correct, I still continued to support my theory. With regard to my general predictions based upon the apsidal differences, I have found them on the whole very correct, and when the forecast has not been so accurate as it might be, I have invariably found that my judgment was at fault.

'In January 1890, on the 20th, I predicted, in the *Mark Lane Express*, the monthly character of the weather for 1890 with great success. Mr. Inskip, a gentleman farmer, living

at Shefford, Beds., observing that I had forecasted a dry September for that year, and noticing that I was correct up to July, planted cauliflowers in abundance, knowing that in September they would meet with a remunerative and ready sale in Covent Garden,—as they did!

'In April 1890 I was invited by the Editor of *Tinsley's Magazine* to write a series of articles on the weather, and give with each article a daily forecast for the next month. I readily agreed to write the series of articles upon my weather-theories, but I demurred to making a daily forecast a month in advance, as I had not before attempted anything so detailed. Eventually I agreed to make the attempt, and as the forecasts turned out better than I had anticipated, I was induced to continue them. Accordingly, six months' daily forecasts appeared in *Tinsley's Magazine*, from June to November in the years 1890 and 1891.

'During August 1891 I prepared a forecast for each day of the year 1892, and this was, later on in November 1891, published as my "Weather-Chart Almanac for the year 1892." Although this Almanac for 1892 entered very fully into the daily weather—giving the general character for each day as "unsettled," "fair," or "wet,"—the hours of sunshine, force and direction of wind, movements of the barometer and temperature for each day, it was correct fourteen out of fifteen times, *i.e.*, there was a ninety-three per centage of accuracy.'

There is no need to weary the reader with details of all the vaticinations which have been made since 1890 by Mr. Clements. Some of them, in the chapters concerning earthquakes, volcanic eruptions, and wind-storms, have already found record in these pages. But there are some others which, were they not independently verifiable, would be hardly to be believed, and were they not founded on immutable law would be quite impossible. From a great mass of evidence I take for first consideration that

portion which relates to the year 1897. It was the year of the late Queen's Jubilee. What would the weather be on the auspicious day of the procession, the 22nd of June? Here is the prediction made many weeks before the day in question, and opposite to it is the actual weather record:

PREDICTION	ACTUAL WEATHER RECORDED AT GREENWICH
(*a*) Morning would be overcast.	(*a*) Overcast till 11 a.m.
(*b*) About seven hours' sunshine.	(*b*) Eight hours' sunshine.
(*c*) Breeze from W.S.W.	(*c*) Breeze from S.W.
(*d*) Barometer 30·00.	(*d*) Barometer 30·04.
(*e*) Solar halo about 2 o'clock.	(*e*) Solar halo in afternoon.

Mr. Clements also predicted a thunderstorm late on that day, or the beginning of the next day, the 23rd, the date on which a storm took place in 1764, exactly 133 years before, or seven complete revolutions of the moon's Metonic cycle of nineteen years, but, as 235 lunations of the moon exceed the golden number by 2 hours 10 minutes, seven cycles would amount to fifteen hours, so that the storm was projected forward into June 24, 1897, when it actually took place near London, and the hailstones completely destroyed the crops in parts of Essex round Ingatestone, as, in a similar area in Middlesex, the crops were destroyed by hail on June 23, 1764.

In this connexion, although it involves a break in chronological order, the forecast for nine days in June, 1902, may be given. These were the days fixed for the Coronation of the King and for the procession through London, and for four days before and three days after. Once more parallel columns may be employed:

CORONATION WEATHER

June, 1902

PREDICTION	GREENWICH RECORD
June	*June*
22. Fine with variable amount of cloud.	22. Very fine with small amount of cloud till afternoon: cloudy after.
23. Fine and partially cloudy.	23. Fine, but generally cloudy.
24. Fine and partially cloudy.	24. Generally cloudless, very fine.
25. Fine.	25. Generally cloudless, very fine.
26. Fine and partially cloudy, with slight rain morning and evening.	26. Generally cloudless, very fine.
27. Fine with some flying clouds.	27. Generally cloudless, very fine.
28. Very fine, bright, and warm.	28. Generally cloudless, very fine and warm.
29. Fine and generally cloudy, unsettled and sultry after.	29. Very fine with little cloud till 11h. a.m.; overcast with frequent rain till 3h. p.m.; fine and partially cloudy afterwards.
30. Very fine, bright, partially cloudy, hazy and sultry.	30. Very fine with small amount of cloud till 5h. p.m.; overcast after.

Mr. Clements remarks:

'My predictions of the weather for the *day* from 6h. a.m. to 6h. p.m. agree almost absolutely with those records kept at Greenwich. I got the brisk winds that prevailed round the 25th and 27th, when I predicted flying clouds.

'I also got the heat of the 29th and 30th, when I predicted sultry weather.

'For the thirteen days from the 17th of June to the end

of the month there is very slight, if any real, discrepancy between my predictions for the early morning, evening, and night and the Greenwich records.

'In fact, it would barely be possible to give a better description of the general character of the weather *now* than that predicted by me.'

In the recorded weather for June 26 and Mr. Clements' forecast there is not absolute identity. The Greenwich record gives:—'Generally cloudless, very fine' ('generally cloudless,' be it noted). Mr. Clements predicted: 'Fine, and partially cloudy, with slight rain morning and evening.' Why was there even this discrepancy? The reader will learn if he will observe how the actual prediction for the 26th was arrived at. In reply to my comment, on July 11, as to the divergence, Mr. Clements sent me the following explanation:

'Considering that the prediction for 26th June was based upon the transit, parallax, and declination, of the moon and sun, and that these factors are never more than very approximately the same it follows that to predict slight rain less than one-hundredth of an inch is somewhat risky, although I can point to some beautiful examples, when slight rain, a few drops, actually occurred as predicted. However, the fulfilment or non-fulfilment of a non-recordable amount of rain does not really affect the accuracy of the prediction, as there was no recordable rain predicted and none fell. It was really cutting the prediction too fine, and, under the circumstances, it would probably have been better to have either predicted slight unsettlement before 6 a.m. and after 6 p.m., or, better still, to have omitted the reference altogether. The main thing was the prediction of the fine day, which was verified. In all my predictions I have a habit of going into too many little details, that are really non-essential and which have been sometimes seized upon by those who are sceptical to insinuate some flaw in a forecast that was otherwise correct.'

ASCOT WEATHER, 1902

'I made a prediction for Ascot Week by request of the Editor of the *Morning Post.*

'During Ascot Week the barometer rose on the 17th, went up to a maximum on the 18th, and fell on the 19th and 20th; rose on the 22nd, culminated on the 25th, fell on the 26th, rose again on the 27th, fell on the 28th and 29th, and was still low on the 30th, all as predicted.

'The prediction of the movements of the barometer from the 17th to the end of June was, therefore, correct.

'With regard to the weather I predicted it for the day, generally from 6h. a.m. to 6h. p.m. for the morning or early morning, and for the evening and night.

'Of the predictions, those for the day are the most important, those for the early morning and night being quite subsidiary.

'My predictions for the 17th, 18th, 19th and 20th agreed with Greenwich.'

Five Months of Continuous Prediction.

On July 17, 1897, Mr. Clements issued a prediction of the movements of air-pressure and rainfall for London from August 1 to December 31 of the same year. In addition to supplying copies to many of the journals in the United Kingdom and sending one to the library of the Meteorological Office, Mr. Clements, on the same day in July, placed a copy with the authorities at the British Museum. I have seen that copy and have verified what I now publish by comparison with the original document. I find the two documents, so far as they relate to the prediction, agree in all respects. The reader's most careful examination of the diagrams (barometrical and rainfall prediction) on page 291 is requested. The explanations which follow apply also to the frontispiece, where the same diagrams appear in colour for facility of identification of their features.

On January 1, 1898, Mr. Clements, with pardonable

self-satisfaction, issued the following circular, which gives particulars concerning the two diagrams:

AIR-TIDAL MOVEMENTS.

'On July 17 last I predicted that the Tidal Movements of the air over London, from August 1 till the end of the year, as indicated by the barometer, would correspond with the upper curve marked C. There can be no doubt about the genuineness of this prediction, because I hold a receipt that the curve marked C was received at the British Museum immediately after its issue last July, where it may still be seen; this curve was also then sent to the editors of the leading newspapers in England, and to the Library of the Meteorological Office, etc., etc. The lower curve marked G gives the movements of air-pressure as recorded by the barometer at Greenwich under the superintendence of the Astronomer Royal.

'The letters *a*, *b*, *c*, etc., placed underneath the curves indicate the corresponding movements. In my Weather Notes, issued on September 4 last, it was stated, and published in the *Standard*, that it would scarcely have been possible to draw a barometric curve more accurately at the end of August than that predicted by me before the commencement of that month.

'The chances against the continued correctness of a predicted curve for thirty-one days in succession are a million to one; my successful prediction, I maintain, proves that the air-movements are controlled by the moon, as my predictions are solely based upon her motions, and the continued accuracy, for four more months day after day till the end of the year, of this curve, emphasizes this fact *ad infinitum*.

'After drawing the predicted curve in July, I wrote the letter *r* over those parts of the curve where I anticipated it would rain, and after an examination of the Greenwich curve, over which *r* also represents the actual rainfall, it will be found that my predictions were remarkably accurate.

FORECAST OF BAROMETRIC CURVE FROM AUGUST 1 TO DECEMBER 31, 1897.

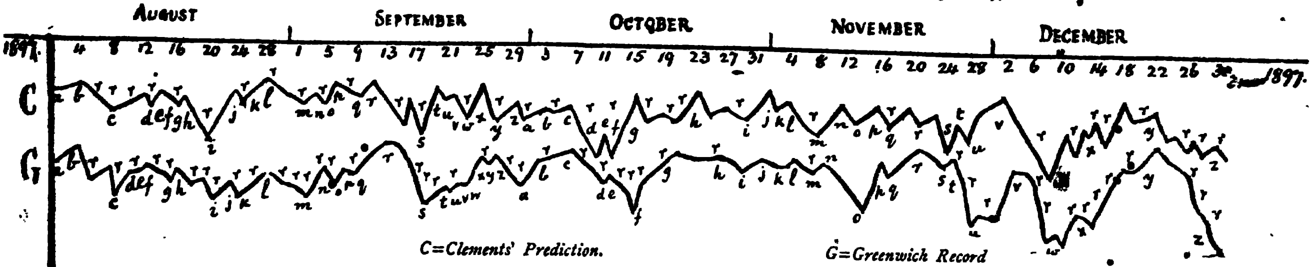


FIG. 64.

FORECAST OF RAINFALL FROM AUGUST 1 TO DECEMBER 33, 1897.

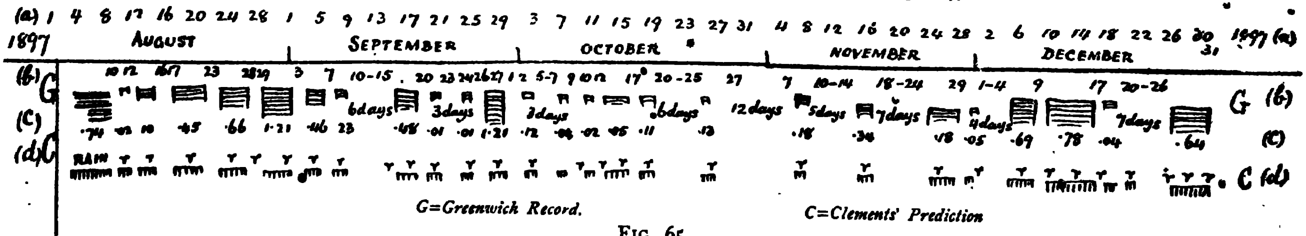


FIG. 65.

'My prediction for rainfall made on July 17 reads as follows: "For about a week in August the weather will be fine, but about the 8th and after that date until about the end of the third week in October it will be unsettled with frequent rains. November will, on the whole, be a fine month, and December will be unsettled from about the 8th to the 16th, and from the 26th to the 31st." During August nearly three inches of rain fell on twenty days, and during September rain fell on seventeen days, so that I was undoubtedly correct for August and September. The unsettled weather in October ended on the 19th, and up to that date rain was recorded on ten days; thus there was, as predicted, unsettled weather with frequent rains from about August 8 till about the end of the third week in October. During the last twelve days of October it only rained once. During November only about one inch of rain fell on ten days, so that the latter part of October and November was fine, as predicted, so far as rainfall was concerned. As about 1½ inches of rain fell from the 7th to the 16th December, and about the same amount from the 26th to the 31st, it follows that my prediction was also correct for that month. In fact, at the end of the year it would scarcely be possible to give a more accurate description of the weather for the last five months than is given in my prediction made last July.

'*January* 1, 1898. '(Signed) HUGH CLEMENTS.'

A few days later another circular was prepared and circulated. It was in these terms:

'VERIFICATION OF RAINFALL PREDICTION.

'On July 17, 1897, I issued a prediction of the movements of air-pressure, rainfall, etc., for London, from August 1 to December 31, 1897.

'In my circular, dated January 1, 1898, I pointed out the almost complete similarity between the actual and the predicted curve of the movements of air-pressure as indicated by the barometer at London.

'In this circular I wish more especially to point out the extreme accuracy of my prediction as to the rainfall in London, from August 1 to December 31, 1897.

'On line (*d*) of the accompanying diagram the letter *r* denotes rainfall, and in each case of predicted rain this letter is placed under the date or dates given on the line marked (*a*). It will be observed that these predictions agree with the actual rainfall for the day or days indicated on line (*b*) as recorded at (G) Greenwich, the amount of rainfall for each day or group of days being given on the line marked (*c*). The day or days on which it rained are marked thus: ———

'Besides being given for each particular day or group of days as shown on line (*d*) C, my prediction of rainfall was on July 17, 1897, summarized as follows, viz.: "For about a week the weather will be fine, but about August 8 and after that date, until about the end of the third week in October, it will be unsettled with frequent rain, with breaks of finer days; November will, on the whole, be a fine month, and December will be unsettled from about the 8th to the 16th, and from the 26th to the 31st."

'With the exception of occasional intervals of twenty-four or forty-eight hours, there were, from August 8 to October 20, only two breaks of three days, and one of six days (as shown on diagram), otherwise there were six inches of rain during these seventy-two days, but from October 20 to November 25, thirty-six days, there was only a little over half an inch of rain, and there were breaks of six, twelve, five, and seven, days without rain. For thirty-six days, from November 25 to December 31, there were only breaks of four days and seven days without rain, the rainfall being over 2½ inches.

'The period over which the prediction was made (five months) is sufficiently long to prove that the rainfall for any given place can be predicted with certainty and accuracy by my system, which is altogether a scientific one.

'(Signed) HUGH CLEMENTS.'

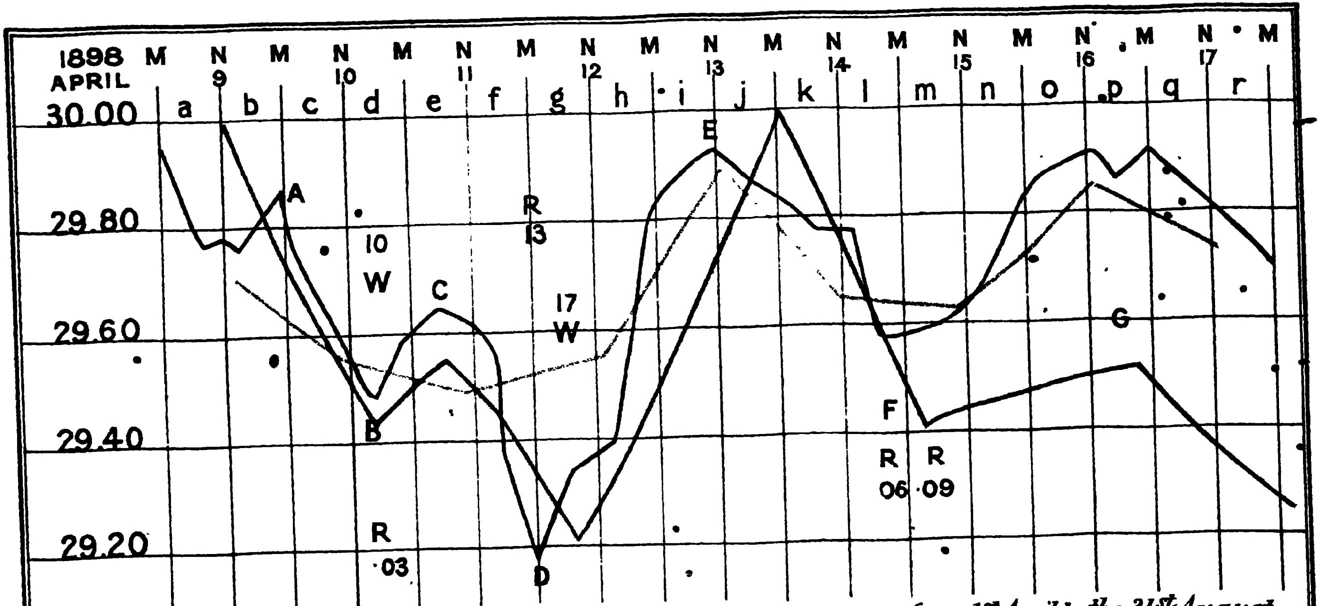
I will trouble the reader with only one more of Mr. Clements' circulars. Enough, with this addition, will have been produced in these pages to carry conviction to the thoughtful and candid reader. How these records compare with the recorded workings of other laws in the solar system, will appear immediately. On April 23, 1898, Mr. Clements sent out this circular:

'VERIFICATION OF MY EASTER WEATHER PREDICTIONS, 18

'In the diagram facing this page the amount of air-pressure as indicated by the barometer, is given to the left from 29·20 to 30·00 inches, and the vertical lines under the dates given at the top represent the time of noon, while the perpendicular lines between the dates stand for the moment of midnight.

'My predictions issued on April 4 were based upon the red curve. The four downward movements predicted are respectively given under the lettering at the top, viz., *cd*, *fg*, *kl* and *qr*, and the three upward will be found under *de*, *hi* and *no*. The downward predicted movement of the barometer on Easter Sunday is indicated on the curve from A to B, and was the immediate cause of the wind W in force 10 at Greenwich, and the rain R ·03 in. during the afternoon, when the air-pressure was as represented at B on the diagram.

'The increase of air-pressure late on Sunday and early on Easter Monday is denoted by the curve from B to C, after the rain inaugurated the temporary improvement of the weather, which I forecasted for the 11th inst. up to ten o'clock at night, when the rapid fall was the immediate cause of the rain R ·13 in., which lasted till the Tuesday morning. This rapid fall of the barometer to the point D was the cause of the wind W, in force 17. The part of the rise of the barometer from D to E overcame the threatening conditions of Tuesday morning, the 12th inst., and sustained the fineness of the weather till



The curve in red is an exact representation of portion of my predicted curve from 1st April to the 31st August published on 14th February 1898 and prepared more than a year before.
The black curve represents the recorded movements of my barometer at Dulwich from Midnight to Midnight for each day.
The green line indicates the mean height of the standard barometer kept at the Royal Observatory at Greenwich. H.C.

late on the Thursday and the morning of Friday, the 14th, when the rapid fall down to F induced the rain that was forecasted. The barometer rose as predicted on Friday and Saturday and fell on the 17th, producing threatening appearances on the afternoon of that day. The predicted lowest points on the red curve at B, D, and F, occur very close to the time of the recorded black curve, and the highest points at C, E, and G, are also remarkably exact. In fact the actual weather experienced was the verification of my predictions in every respect. There was fine weather also, as I predicted, from the 4th to the 9th inst. And, considering that I have found it possible to predict the weather day after day for the whole of the year in advance, it appears strange that the general scientific opinion still is that the weather cannot be predicted for more than twenty-four hours, and that the record of success of the Meteorological Office on their own showing was only 54 per cent. for the United Kingdom during last year.

'P.S.—With regard to my prediction of an earthquake on the morning of the 17th inst., I have to say that in 1897, 1896, 1895, 1894, 1893, 1892, 1891, 1890, in the month of April, when the lunar and solar positions were similar, there were earthquakes in either Greece or Italy, or both, but although this year the line of greatest seismal effect passed along the parallel of 46½° N. lat., and over countries where earthquakes seldom occur, still tremors or shocks of greater or less force must have occurred between 40° and 46° N. lat.'

I submit, for the consideration of all whose business it is to weigh evidence and to decide issues according to the evidence produced, whether the theories advanced by Mr. Clements have not become verified facts upon which future action may be taken. I especially appeal to two authorities, Professor G. H. Darwin and Professor Sir Robert Ball.

Professor Darwin, in his *The Tides and Kindred Phenomena in the Solar System*,[1] has a chapter devoted to the degree of accuracy of tidal prediction.[2] He states that the success of tidal predictions varies much according to the place of observation. 'They are,' he continues, 'not unfrequently considerably in error in our latitudes and throughout those regions called by sailors "the roaring forties." The utmost that can be expected of a tide-table is that it shall be correct in calm weather and with a steady barometer.' Notwithstanding perturbations, good tide-tables, he says, are usually of surprising accuracy even in northern latitudes. In proof he gives a table showing the results of comparison between prediction and actuality at Portsmouth. It is shown that, in the months of January, May, and September, 1897,[3] there were 177 errors in time, ranging from 0m. to 5m. sixty-nine times, 6m. to 10m. fifty times, 11m. to 15m. twenty-five times, 16m. to 20m. ten times, 21m. to 25m. eleven times, 26m. to 30m. seven times, 31m. to 35m. four times, and 52m. once. As regards errors in height for the same period there were exactly the same in number as the time errors, 177, in these proportions:

INCHES.	No.
0 to 6	89 times.
7 ,, 12	58 ,,
13 ,, 18	24 ,,
19 ,, 24	6 ,,

[1] London: John Murray, Second Edition, July, 1901.
[2] Pp. 219–226.
[3] It is, at least, a singular coincidence, that the observations in question were made in the same year as that in which Mr. Clements was achieving his most conspicuous successes, January to September, 1897.

For the whole of the year 1882, excepting part of July, the magnitude of error and the number of instances were:

Inches.		No.
0 to 6	. . .	381 times.
7 „ 12	. . .	228 „
13 „ 18	. . .	52 „
19 „ 24	. . .	8 „
31	. . .	once.

Like irregularities and discrepancies for Aden are also given in detail, the conclusion as to heights being that 'out of 116 predictions the error in the predicted height was equal [? to] or less than two inches in 92 cases; it amounted to three inches in 14 cases, and in the remaining 11 cases it was four inches.' 'It thus appears' (he adds) that, 'as regards the height of the tide also, the predictions are of great accuracy.'

Mr. Darwin concludes his chapter with two paragraphs which, in their bearing on the almost absolutely accurate prediction by Mr. Clements, over long periods, of weather conditions, would seem to show that, in the Professor's words, he has 'lighted on the true causes of the phenomena,' and that his success 'is, therefore, a guarantee of the truth of the theory.' It may be added, again in Mr. Darwin's own words, applied in a new direction, Accurate weather prediction, Mr. Clements' principles of prediction being what they are, based wholly upon the movements of certain bodies belonging to the solar system and the attractive influence they exert, is 'one of the greatest triumphs of the theory of universal gravitation.' Mr. Darwin (pp. 225–226) says:

'If our theory of tides were incorrect, so that we imagined

that there was a partial tide-wave of a certain period, whereas in fact such a wave has no true counterpart in physical causation, the reduction of a year of tidal observation would undoubtedly assign some definite small height and some definite retardation of the high water after the passage of the corresponding, but erroneous, satellite. But when a second series of observations is reduced, the two tidal constants would show no relationship to their previous evaluations. If then reductions carried out year after year assign, as they do, fairly constant values to the tidal constants, we may feel confident that true physical causation is involved, even when the heights of some of the constituent tide-waves do not exceed an inch or two.

'*Prediction must invariably fail, unless we have lighted on the true causes of the phenomena*; SUCCESS IS THEREFORE A GUARANTEE OF THE TRUTH OF THE THEORY. When we consider that the incessant variability of the tidal forces, the complex outlines of our coasts, the depth of the sea and the earth's rotation are all involved, we should regard good tidal prediction as *one of the greatest triumphs of the theory of universal gravitation*.'[1]

Sir Robert Ball, in *The Earth's Beginning*,[2] devotes much of his space to a demonstration of the correctness of the nebular theory in the evolution of the solar system. Laplace, he states, mainly placed his belief in that theory on some remarkable deductions from the theory of probabilities. Sir Robert Ball allows for the great weight of those deductions, but proceeds to set forth a number of instances in the solar system which give such force to the theory that it becomes a certainty, demonstrated beyond

[1] The present writer, and not Professor Darwin, is responsible for the emphasis given, in this paragraph by the use of italics and small capitals, to certain passages.

[2] *The Earth's Beginning*, by Sir Robert Stawell Ball, LL.D., F.R.S. Cassell and Co., Limited, 1901.

all cavil. After arguing as to the impossibility of such arrangements as are found in the planets having originated by chance, the most popular of living astronomical expositors proceeds to say:

'The chances against their having thus occurred are 10,000,000 to 1. Hence we find it reasonable to come to the conclusion that the arrangement, by which the planets move round the sun in planes which are nearly coincident, cannot have originated by chance. There must have been some cause which produced this special disposition.' [1]

A few pages later (314–316) Sir Robert continues his investigations into the probabilities based upon nine planets and the sun all turning on their axis in the same direction, and the planets each going round the sun along the same way, using the following striking language:

'It will be useful to study the matter numerically; and the rules of probabilities will enable us to do so, as we may see by the following illustration: We deem the captain of a cricket team fortunate when he wins the toss for innings; we should deem him lucky indeed if he won it three times in successive matches. If he won it five times running his luck would be phenomenal; while, if it was stated that he won it ten times consecutively, we should consider the statement wellnigh incredible. For, it is easy to calculate, the chances against such an occurrence are one thousand and twenty-four to one. In like manner we may say, that for nine planets and the sun to all go round in the same direction would be indeed surprising if the arrangement of the planets had been determined by chance; there are more than a thousand chances to one against such an occurrence.

'But Ceres was only the earliest of many other similar discoveries. And as each asteroid was successively brought

[1] *Ibid.* pp. 305, 306.

to light, it became more interesting to test whether it followed the rest of the planets in that wonderful unanimity in the direction of their movements of revolution, or whether it made a new departure by going in the opposite direction. No such exception has ever yet been observed. Let us take, then, ten more planets, in addition to those we have already considered, so that we have now nineteen all revolving in the same direction as the sun rotates. It is easy to compute the probability that these twenty movements should be all in the same direction, if, indeed, it were by chance that their directions had been determined. It is the same problem as the following: What is the chance that twenty coins, taken in the hand and tossed into the air at once, shall all alight with their heads uppermost? We have all seen that the chances against this occurrence, if there were ten coins, is about a thousand to one. It can easily be shown that if there were twenty coins the chances against the occurrence would be a million to one. We thus see that, even with no more than nine planets and the sun, there is a million to one against a unanimity in the direction of the movements if the determination of the motion was made by chance. We may, however, express the result in a different manner, which is more to the purpose of our argument. There are a million chances to one in favour of the supposition that the disposition of the movements of the planets has not been the result of chance; or, we may say that there are a million chances to one in favour of the supposition that some physical agent has caused the unanimity.

'We can add almost any desired amount of numerical strength to the argument. The discoveries of minor planets went on with ever increasing success through the whole of the last century. When ten more had been found, and when each one was shown to obey the same invisible guide as to direction in which it should pursue its elliptic orbit, the chances in favour of some physical cause for the unanimity became multiplied by yet another thousand. The probability then

stood at a thousand millions to one. As the years rolled by asteroids were found in ever increasing abundance. Sometimes a single astronomer discovered two, and sometimes even more than two, on a single night. In the course of a lifetime a diligent astronomer had placed fifty discoveries of asteroids, or even more than fifty, on his record. By combined efforts the table of the asteroids has now approached five hundred, and out of that huge number of independent planetary bodies there is not one single dissentient in the direction of its motion. Without exception whatever, they all perform their revolutions in the same direction as the sun rotates at the centre. When this great host is considered, the numerical strength of the argument has attained a magnitude too great for expression. Each new asteroid simply doubled the strength of the argument as it stood before.'

It hardly seems necessary that one should discuss whether, according to the mathematical theory of probability, Mr. Clements' success in his predictions has established the certainty of the law he promulgates. 'Probability, which necessarily implies uncertainty, is a consequence of our ignorance.'[1] But, in the case before us there remains no room for uncertainty. When such results follow from a predicted course as Mr. Clements has obtained, and are verified, as in this instance, by the Greenwich records made after the event, and made of course in relation to nothing but a desire to state actual weather-conditions, it is not possible for a candid mind to conceive aught than that they have been produced as the outcome of an invariable law. If it be the fact that 'the truth of no conclusion can rise above that of the premisses, of no theorem above that of the data,'[2] the

[1] *Encyc Brit.*, Ninth Edition, vol. xix., art. 'Probability,' p. 768. [2] *Ibid.*

converse is equally undeniable, namely, that no conclusion can (in the temple of truth and by seekers after accuracy) escape from its demonstration or a theorem from its data. So regarded, I submit that, alike by the laws of probability and by the reasoning of the two great scientific men whose dicta I have recited, Mr. Clements' theories have become a demonstrated law of Nature.

Professor Darwin is satisfied that the truth of the gravitational theory of the causation of tides by lunar attraction is guaranteed even though out of 184 times of high water at Portsmouth, England, investigated by himself, there are 177 errors as to time and the same number of errors as to height. Mr. Clements predicts the weather for 153 consecutive days, and states there will be rain on a certain number of those days, and on and about certain days within the covering period, while there will be fine weather on the other days. He is wrong to the extent of predicting rain for two days out of the whole period when the subsequent record showed no rain.

COMPARISON OF TIDAL AND RAINFALL PREDICTION.

TIDES.	RAINFALL.
177 errors out of 184 tides.	Two errors on two days out of 153 days.

Again, as to barometrical rise and fall, as will be seen by examination of the diagram, the identity between prediction and record is remarkable. No possible guessing, no chance or probability, could have produced such unison; the forecasts are only thinkable, only conceivable, as the consequence of unvaried law.

Sir Robert Ball is content to consider Laplace's theory

of gravitation and of the origin of the solar system absolutely established because the movements of nine planets and the sun agreed in support of that theory. The five hundred asteroids he regarded as mere surplusage, something in the nature of the gilding of refined gold, of the painting of the lily. He even considered that the contrary testimony furnished by the motions of the moons of Uranus and the satellite of Neptune [1] to be testimony in favour of the nebular hypothesis. Given more time, he says, and these bodies will come into harmony with the rest.[2]

Once more a comparison :

THE NEBULAR HYPOTHESIS.	THE CLEMENTS DISCOVERY.
Nine planets and the sun, each rotating on its axis in one direction and (in the case of the planets) in proceeding the same way round the sun, showed 1,000,000 to 1 in favour of the truth of the theory.	One example, out of many, a prediction for 153 days in 1897, from August 1 to December 31, almost absolutely correct. The chances against this result being secured otherwise than by the operation of natural laws are 1,000,000, 000,000,000,000,000,000,000, 000,000,000,000,000,000 to unity.

[1] '. . . The direction of motion of the satellite in this track is antagonistic to all the other movements in the solar system.'—*The Earth's Beginning*, p. 340.

[2] 'The present anomaly will then tend to become evanescent. for, as the exhaustion of the energy continues, the planes of the satellites of Uranus will gradually come into conformity with the plane of the ecliptic. We make no doubt there may be a similar explanation of the movements of the satellite of Neptune. The inclination of the plane of the orbit of the satellite to the ecliptic is probably now increasing. It will ultimately come to be at right angles thereto, and then the next advance

If absolute proof be the pre-requisite for belief in, and acceptance of, the Clements theory surely that absolute proof has been furnished. Probability represented by seven figures to one is regarded as 'strong as Holy Writ,' stronger than aught of man's devising, strong as the solid ground of Nature itself; shall Probability, represented by forty-five figures to unity, be less certain?

2. WHAT IS IT THAT MR. CLEMENTS IS READY TO DO?

First, although recognition and reward are as sweet to him as to any man, Mr. Clements has never used his discoveries only for his own profit. He has been as prodigal with his painfully-acquired knowledge as is the sun with its light and heat. He has been profuse in his endeavours to share his knowledge with the world at large. For nineteen years he has given up every hour of his spare time, even to the stinting of his hours of rest, and knowing few hours for recreation, or none at all, to make known a law of causation which, once accepted and acted upon, would add enormously to the wealth, first, of individuals countless in number, and next, of all countries. So far as the present writer's connexion with Mr. Clements has served to show, that gentleman's unselfishness has been his most marked characteristic.

But, surely the time has passed when a proved theory of vast public value,—a theory which, put into practice, would become a literal saviour from death of millions upon millions of British subjects in India, which would

of the plane will convert, by a continuous action, the retrograde motion of the satellite, at present so disconcerting, into a direct motion. The change of the plane will still continue until it, too, may ultimately coalesce with the ecliptic.'—*Ibid.* p. 346.

warn Australian sheep-masters of coming drought and of the subsequent welcome rains, which would make British agriculture less of a chance and more of a business than it now is, or, in existing conditions, can ever possibly become,—shall be allowed to languish for lack of proper recognition and adequate support.

It is, regarded from the point of view of early adoption, one of the merits of the newly discovered law that it does not run counter to any vested interests. Let it be adopted to-morrow and not a single officer in the Meteorological Department in England, in the United States, in every country where meteorology is studied, need be discharged. All that would be required would be that the present confessedly haphazard and empirical method of forecasting the weather should be discarded and in its place a truly scientific method be substituted. Many of the clerks now employed in collating the figures coming in hour by hour by telegraph would become computators for the new system, while not only would there be no need to set aside any existing meteorological observatory, but rather would it be found desirable to establish additional ones. Upon the accurate record of present-day conditions, as much as upon a knowledge of the perturbations of the moon and the adjusting of movements which change with the changing order of the universe, depends accurate weather forecasting. The change caused by the adoption of the Clements system proceeds along the line of least resistance, disturbing no single man in his holding, but, in its every form, benefiting the whole human race.

This new application of natural (but unseen) law is not confined to any one country or to any one people. Not the least of the merits of the Clements discovery is that it is of universal application, with this difference only—it will be of greater benefit to the land in which accurate meteorological observations have been made for a long series of

years than in lands where this has been but partially done, or, as may even be, has been wholly neglected. It is, moreover, a diversion of the knowledge of natural law to the benefit of humanity, which, the longer the knowledge is made use of the more it becomes a gain to mankind. It is not possible to conceive greater material advantages having been derived from any discovery in recent centuries, or perhaps at any time in the world's history.

Why should not the British Government make use of the present opportunity to rightly equip the Forecasting Branch of the Meteorological Office, furnish it with an adequate staff of computators, and thus constitute it one of the most valuable assets of an Empire three-fourths of whose populations—taking in the Dominion, the Commonwealth, India, and the Crown Colonies—depend upon agriculture, that is, upon the weather, for their daily bread? If we take the United Kingdom only, who that knows anything of the mischances caused by bad weather can doubt that a foreknowledge of the weather for a single year would be worth many millions of pounds sterling? If we include the Colonies and India, the total amount of benefit would be almost incalculable. A wet or a dry season depends upon the movements of the barometer, which, in its turn, depends upon the moon's motions. If the barometer is comparatively high and steady there will be a fine and dry season, but if the barometer be comparatively low and unsteady the weather will be unsettled and wet. The height can now be known which the barometer, on any given day, will record. In India a good or a bad monsoon depends upon the height of the barometer, and as we can now calculate the daily height of the barometer for several years ahead, we can absolutely foretell when there will be a bad monsoon. Take Bombay. The annual average height of the barometer in that city is 29·82. During the

months of November, December, January, and February, the barometer is above the average and dry weather prevails, and there is no great drop in its height till June, when the monsoon begins and continues in July, after which the barometer, on the average, gradually rises, and the monsoon slowly disappears. The average fall of the barometer in June at Bombay is ·17 inches, in July ·16 inches, and in August ·09 inches. Now, if the fall of the barometer be much less at Bombay in June, July, and August, there would be little rain, and consequent famine, but if the fall be much greater there would be abundance of rain, and, consequently, abundance of crops. As reliable weather records are available for every Indian Province, the Government of India ought to lose no time in calculating periods of drought, and the Home Government ought to put the matter in hand for the United Kingdom and the over-sea dominions of the British Empire.

Upon the Government of India the responsibility for using so potent a means of beneficial rule is great. So much is this the case that it is hardly conceivable, now that the trustworthiness of the Clements system has been demonstrated, that the Viceroy of that Empire will delay to turn Mr. Clements' knowledge to useful account. As for the other portions of the British Dominions, whether in the United Kingdom or in the Britains over seas, the issues are dependent upon the expression of public opinion. I can scarcely permit myself to believe that, once an accurate means of forecasting weather for years ahead is available, the present hand-to-mouth, admittedly untrustworthy, system will be allowed to continue. Rather, may it be anticipated that the tools will be given to the man, who alone among the many millions of British subjects, has proved himself capable of using them, and that he will be told to do for the farmer what the tide-predictor now does for the mariner.

As regards the continent of Europe I do not doubt that the system, when it has been brought to the notice of the various authorities, will be adopted in France, and Germany, and Austria-Hungary, and Italy, and Russia—indeed everywhere. Probably, though it may have the misfortune (in the eyes of some) to be the discovery of an Englishman, it may be adopted in all those countries before it is adopted in England. The world will not, in these days, when wealth counts for so much in national existence, the nations having become convinced, be so foolish as to allow so potent a weather-indicator to remain unused. Probably nowhere in the world could the Clementian discovery be rapidly turned to such good account as in France. The great astronomer Leverrier not only discovered—simultaneously with Adams—a planetary addition to the solar system, but he did practical meteorological work for his country. He

'was not only the keenest-sighted of physicists, but also the prince of organizers of systems of meteorological observation. His last great service to the science was the establishment of a system of observation, by which the propagation of hail, rain, and other weather-phenomena could be followed and recorded from commune to commune over France. This scheme for the investigation of the vitally important bearing on the meteorology of a country, of a comprehensive observation of its rainfall, hail, and thunderstorms, through numerous observers possessing sound local information, is not only eminently just in science, but is calculated to be attended with the greatest benefits to agricultural and other public interests.'[1]

With such an organisation at hand to turn the Clements method to account, the agricultural wealth of France may be largely increased within the next few years.

As to the United States, if examination in that country establishes correctness, months only, not years, will surely elapse before the system will be adopted. The American

[1] *Encyc. Brit.*, vol. xvi. p. 158.

people, as a rule, do not fail to turn a good thing to a useful purpose, once that good thing is realized as such. And, the United Kingdom?—ah! the United Kingdom? I can only adapt the words of the Prince of Wales, addressed to the merchants of London, and say: 'Wake up, United Kingdom!'

WEATHER CHARTS FOR THE LATE SPRING AND SUMMER MONTHS OF 1902

MAY

EXPLANATION OF FIG. 67

E E denotes the Equator; MM the moon's course during MAY 1902 with the corresponding dates; G G the meridian of Greenwich; London the position of London $51\frac{1}{2}°$ North; ss and s's' the sun's zenith and nadir course respectively with the corresponding dates.

This diagram shows the moon's declination (over 19°) is greater than that of the sun from the 8th to the 11th, and less than the sun's from 21st to 25th, and that—excepting from the 14th to 19th, 27th to 31st, and from the 1st to the 5th—the sun and moon were in proximity in declination, so that a greater tidal effect was produced with the unsettled showery and cold weather that characterized the month of May. Directly under the curve denoting the moon's course the height of the barometer and the rainfall for each day are given according to the scale in the margin, the rainfall curve being marked by dotted lines. It will be observed that the barometer is highest on 25th, when the moon transits three hours after midnight, and low on 3rd, when the transit takes place three hours before noon. The barometer is lowest on 17th, when the moon transits three hours before midnight, and higher on 10th, when the transit occurs about three hours after noon. The barometer was higher on 7th, when the moon and sun crossed the meridian together, powerfully agitating the atmosphere three hours before and after noon, when these luminaries were at an angle of 45°, so that the heaviest rainfall of the month then occurred. The other heavy rainfalls occurred on 3rd and 17th, when the moon and sun were at an angle of 45°, and again on the 30th, when the moon was at an angle of about 90° with London and on the equator, as on the 3rd. Thus there were three heavy rainfalls with a low barometer, and one with a high barometer. The relative positions of the moon and sun, north and south, from 9th to 11th and 24th to the 27th respectively, were very similar, and there was no rain. The positions on 20th and 21st and the 6th are similar in all respects (barometer, rainfall, and moon and sun curves), and so are the 8th and 22nd; 13th and 14th agree with 28th and 29th; thus in every case a connexion may be shown between rainfall and the curves.

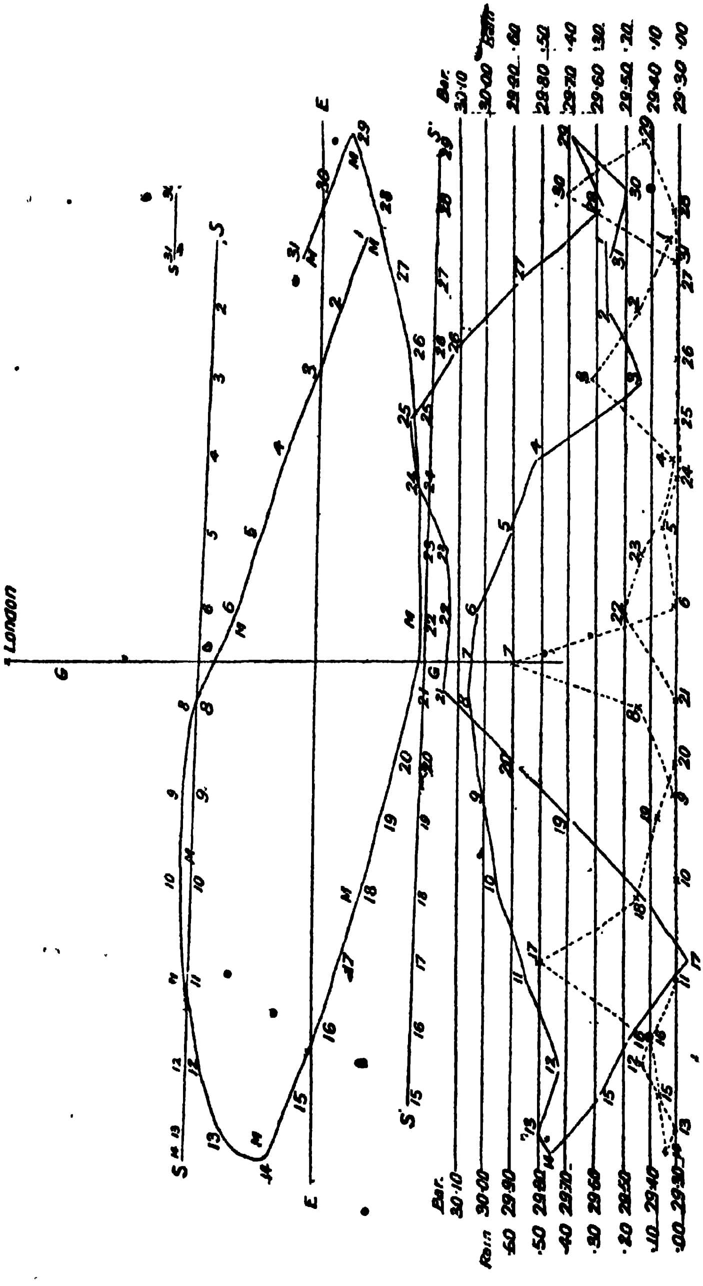


Fig. 67.
MOVEMENTS—SUN AND MOON; BAROMETRICAL AND RAINFALL CURVES (GREENWICH RECORDS). MAY 1902.

WEATHER CHART FOR JUNE, 1902

EXPLANATION OF FIG. 68

E E denotes the Equator; M M the moon's course during JUNE 1902, with the corresponding dates; G G the meridian of Greenwich; L the position of London $51\frac{1}{2}°$ North latitude; S S and S′S′ the sun's zenith and nadir course respectively with the corresponding dates. This diagram shows that the moon's declination (over 19°) is less than that of the sun for the whole month, and accounts for the fine weather especially during the last half of the month, the first half of the month being showery and unsettled, due to the closer proximity of the luminaries. The barometer is highest on the 24th, the moon being three hours from the sun and 75° in angular distance from London. The barometer is high again on 27th, when the moon is five hours from the sun, and at noon the moon is about 90° in angular distance from London, and fourteen days earlier, on 13th, was lowest, the transit occurring in the evening instead of the morning. The heavier rains occurred on 3rd and 4th, just before new moon, and on the 13th and 14th and 30th, when there was an interval of twelve hours in the time of the moon's transit, the distances of the moon from the equator and from the sun being very approximately equal. There was rain on 20th and 21st under conditions similar to those prevailing on 4th and 6th. The fine weather from 22nd to the 28th was largely due to the widening out of the moon's course from that of the sun.

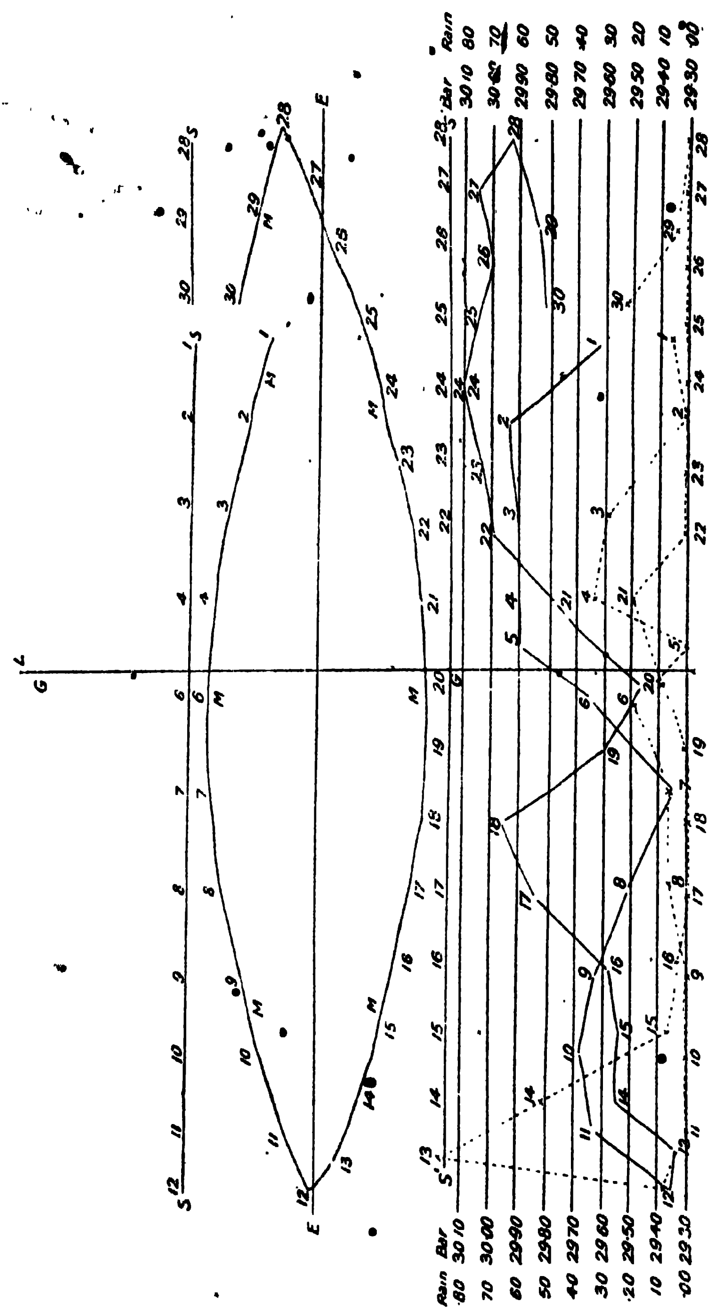


FIG. 68.

MOVEMENTS—SUN AND MOON; BAROMETRICAL AND RAINFALL CURVES (GREENWICH RECORDS). JUNE 1902.

WEATHER CHART FOR JULY, 1902

EXPLANATION OF FIG. 69

E E denotes the Equator; M M the moon's course during JULY 1902, with the corresponding dates; G G the meridian of Greenwich; L the position of London 51½° North latitude; S S and S′S′ the sun's zenith and nadir course respectively with the corresponding dates. This diagram shows that the moon's declination (over 19°) is less than that of the sun for the whole month, but that the moon and the sun approach nearer in declination from the 15th to the 19th. The comparatively fine weather in July was due to the fact that the moon's course, M M, kept well within the sun's course, S S and S′S′. Directly under the curve denoting the moon's course the height of the barometer and the rainfall for each day are given according to the scales in the margin, the rainfall curve being marked by dotted lines. During July the barometer keeps well over 29·80 in., excepting for a few days, and is lowest on the 10th and 26th, when the angular distance from L (London) is exactly the same and almost 90°, and when the moon and sun are about five hours or about 75° apart. Under the same conditions the barometer is low in May, June, and August. The barometer is highest in July on 2nd and 3rd, when the moon is in greatest declination north, and in May when in greatest declination south. There were 1·09 in. of rain during the month; more than half of this amount fell on the 1st and 9th, when the moon was about three hours, or 45°, from the sun. There was a slight and similar fall of the barometer on the 4th and 20th, at the time of new and full moon respectively, but as the moon on the latter occasion was on the anti-meridian and nearer the nadir sun in declination than the declinational differences between those luminaries on the 4th, the barometer was lower on the 20th, and there was some rain. There was also some slight rain from 26th to end of month, due to the rapid fall of the barometer on the 26th, already referred to.

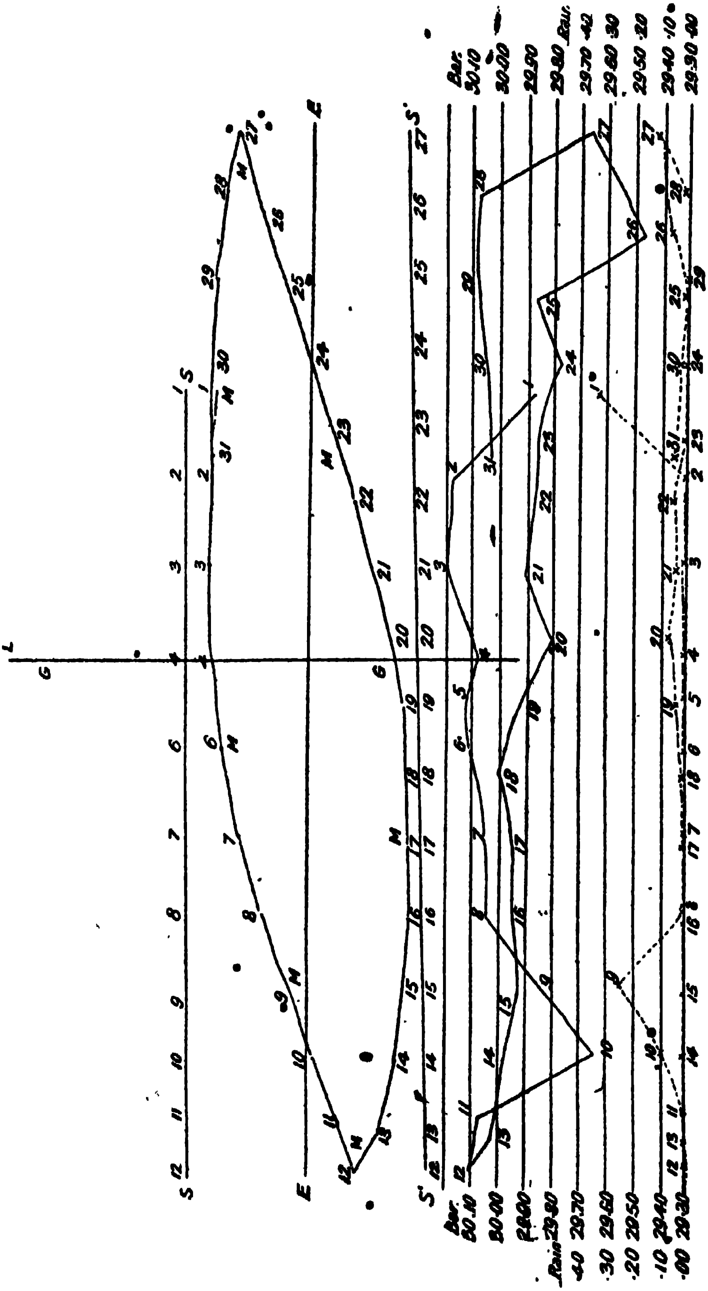


FIG. 69.

MOVEMENTS—SUN AND MOON; BAROMETRICAL AND RAINFALL CURVES (GREENWICH RECORDS). JULY 1902.

WEATHER CHART FOR AUGUST, 1902

EXPLANATION OF FIG. 70

E E denotes the Equator; M M the moon's course during AUGUST 1902, with the corresponding dates; G G the meridian of Greenwich; L the position of London 51½° North latitude; S S and S′S′ the sun's zenith and nadir course respectively with the corresponding dates. This diagram shows that the moon's declination (over 19°) is greater than that of the sun from the 11th to the 17th, and from the 23rd to the end of the month. This contiguity of the moon and sun during so large a portion of the month was the immediate cause of the unsettled weather. There was during August, so far as the sun's and the moon's course was concerned, a reversion to the positions of the month of May, with a repetition of the coldish, unsettled, and showery weather that then prevailed. It will be observed that the barometer was highest when the moon was three hours from the sun and about 60° in angular distance from London at noon, and almost as high on the 9th, when the moon was about five hours from the sun and about 90° in angular distance from London at noon, and, excepting the 1st and 21st (including the 9th and 22nd), the barometer kept under 29·90 and over 29·50. The barometer was low on 7th, when the moon was three hours from the sun and over 70° in angular distance from London. On the 19th the barometer was low when the moon was near the sun and 60° in angular distance from London, and again on the 30th the barometer was low, when the moon, under two hours, was approaching the sun and at an angular distance of 45° from London. The total rainfall at Greenwich for the month was 2·92 inches, and of this amount about two-thirds fell on four days, the 17th, 18th, 19th, and 31st, when the moon was close to the meridian of Greenwich at noon, as may be seen from the diagram, only about 1 in. of rain falling during the remaining twenty-seven days of the month; of this amount ·67 in. fell on the 6th, 23rd, and 24th, so that 2·44 in. fell on seven days, leaving ·58 in, for twenty-four days, twelve of which were rainless. The rain on 23rd and 24th was due to the moon's course crossing that of the sun, and on the 6th the moon crossed the equator at about the same angular distance from London as on 23rd.

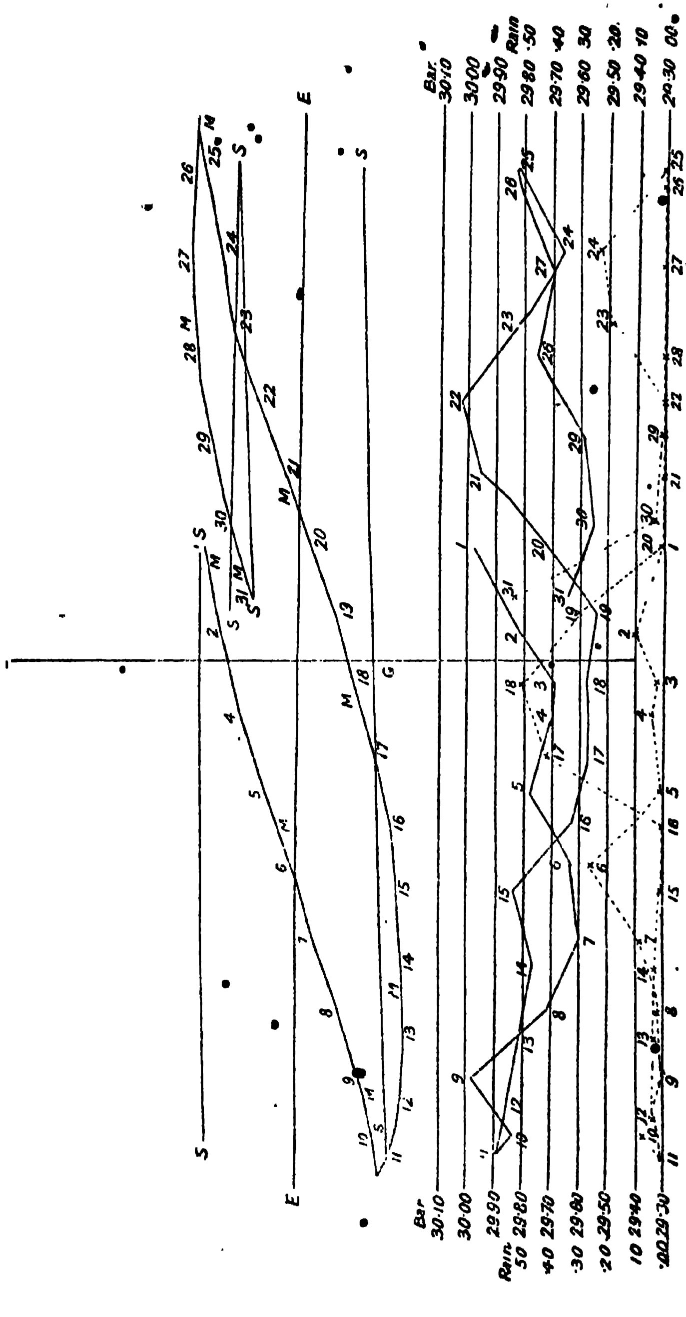


FIG. 70.

MOVEMENTS—SUN AND MOON; BAROMETRICAL AND RAINFALL CURVES (GREENWICH RECORDS). AUGUST 1902.

WEATHER CHART FOR SEPTEMBER, 1902

EXPLANATION OF FIG. 71

E E denotes the Equator; M M the moon's course during SEPTEMBER 1902, with the corresponding dates; G G the meridian of Greenwich; L the position of London $51\frac{1}{2}^\circ$ North latitude; S S and S′S′ the sun's zenith and nadir course respectively with the corresponding dates. This diagram shows that the moon's declination is greater than that of the sun, which varies from 8°32′ N. on the 1st to 2°32′ S. on the 30th, crossing the equator at midnight on the 23rd. From 5th to 15th, and from 18th to 28th it will be observed from the illustration that the moon's course is respectively south and north of the sun, being most remote on the 9th and 24th. As in the preceding summer months, the barometer was highest when the moon transited the meridian of London at 15h. or 21h., just three hours, or 45°, from the anti-meridian or meridian, and that it was low on 3rd and 16th one hour after noon and before midnight, and that it was also low at the corresponding position in August, and particularly in June, during which month there is a great similarity in the movements of the barometer when compared with September. The total amount of rainfall for September was 1·65 in., of which amount 1·45 in. fell in two days, the 10th and 11th, and it is remarkable that on June 13th and 14th, when the positions almost absolutely corresponded, the rainfall should be practically the same in amount, 1·40 in. And, due to the similarity in the movements of the barometer for June and September, the weather was very much alike, especially as regards rainfall.

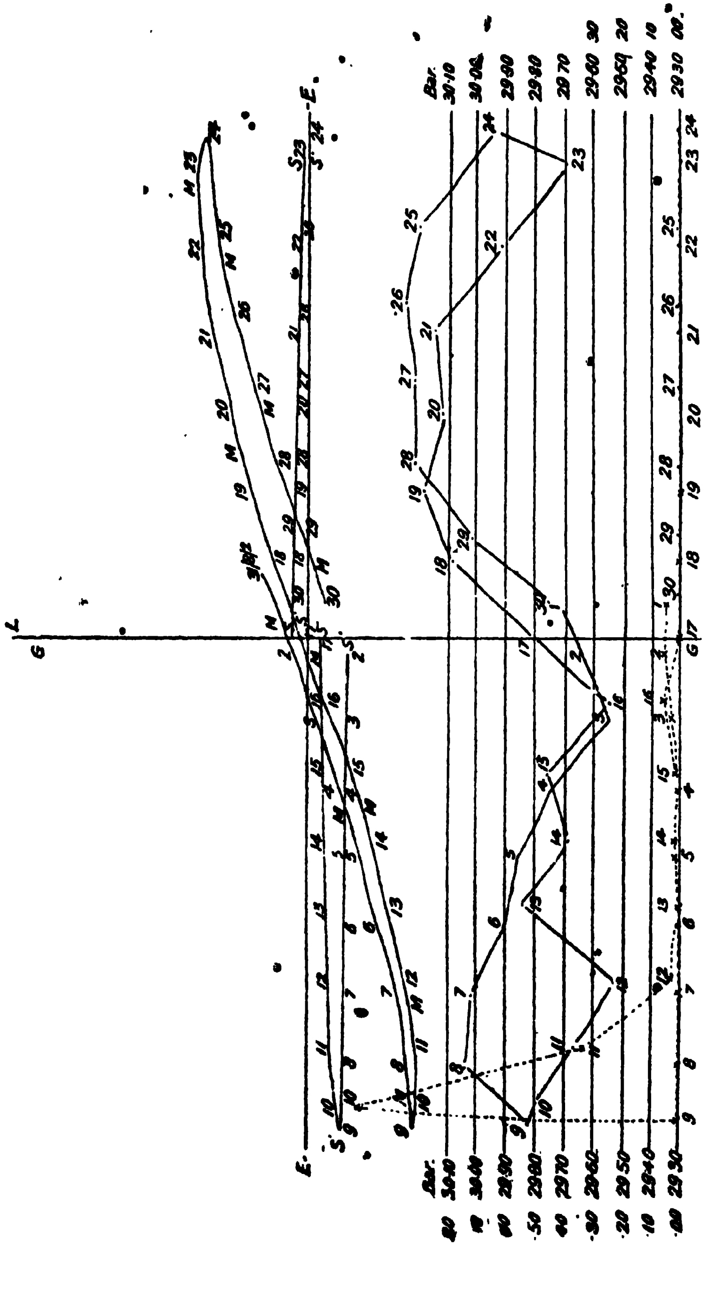


Fig. 71.

MOVEMENTS—SUN AND MOON; BAROMETRICAL AND RAINFALL CURVES (GREENWICH RECORDS). September 1902.

APPENDICES

I

The Principles on which the Weather for Nine Days, June 22 to June 30, 1902, were calculated

(*Prepared in March and April* 1902)

The weather is a function of the movements of the barometer. What I propose to do is to calculate the height of the barometer in London from the 22nd to the end of June, by the method fully described in this work.

Before determining the height of the barometer for any particular day it is necessary to find one or more days in corresponding past years when the various lunar factors were similar. We must find days in the past when there was a similarity in transit, parallax, and declination of the moon. And this similarity can only be found in years that recur in cycles.

For instance, 1716 would be a good year. It would be possible to calculate with approximate accuracy the time of the moon's transit with the corresponding parallax and declination, but this would be unnecessary trouble, as I am unable to obtain accurate details of the daily weather in London 186 years ago, though I know there was a cold dry spring and summer till August 31st. The 186 years' lunar cycle is the most perfect, because it contains the lunar apsidal cycle of 8·86 years, and the lunar nodal cycle of 62 years an even number of times; the only drawback is that the sun does not come back to the same relative position with regard to the earth and moon every 186 years, and thus the weather is not exactly repeated every 186 years.

The next smaller cycle to that of 186 years is that of 133 years, during which there are 7 complete revolutions of the golden number, 19 years, and 15 cycles of 8·86 years' revolution of the lunar line of apsides. But as 235 lunar months differ from 19 years by 2 hours, 10 minutes, 1,645 lunar months differ from 133 years by more than 15 hours, and as 133 does not contain 18·6 an even number of times, the declinations would differ to some extent every 133 years, therefore the

weather would differ in so far as it depends upon slight differences in declination. Notwithstanding, this small difference of declination at intervals of 133 years, there is considerable similarity in the weather of this interval, and the weather this year has been, so far, and will continue to be, similar to that of 1769.

The next lunar cycle in order is that of 130 years. This cycle contains the lunar node cycle of 18·6 years just 7 times, and is a multiple of the 10 and 13 years' lunar cycles. The weather of 1902 and of 1772 is so similar that there were small-pox epidemics in both years. There is also another lunar cycle of 93 and 75 years, both fitting in with the 18·6 node cycles, the former being a multiple of 31, and the latter formed of 62 and 13 years' cycles. The years 1809 and 1827 are respectively 93 and 75 years from 1902. The cold in February, and the rainfall in March, 1827, closely corresponded with the same time this year.

From 1827 up to 1884 there is no year in which the declinations correspond sufficiently to be utilised for calculating the height of the barometer.

The 31 years' cycle, when the opposite phases of the moon take place at the same time of the day a few days later in the month, is composed of two cycles of 18 and 13 years.

The year 1884 is 18 years from 1902, and is used with 1769, 1772, 1809, and 1827, to find the height of the barometer for the days of the present year.

Before using the heights of the barometer given for 1769, 1772, 1809, and 1827, it will be necessary to test them for accuracy, as it is only reasonable to suppose heights so many years ago would not be so correct as the mean heights recorded at the Greenwich Observatory in more recent years.

Let us compare June 21, 1769, with June 24, 1884:

	Transit.	Parallax.	M. Dec.	S. Dec.	Differences.		Bar.
24/6/1884	1·19	60·12	16·42N	23·24	6·42	40·6	29·78
21/6/1769	14·8	55·17	16·42	23·27	6·45	40·9	29·60
Difference	0·49	4·55	0·0	0·3	0·3	0·3	
	—2	—15			—½	—½	

In this case the total of the minus quantities amounts to ·18, which is the difference in the heights of the barometer on those two days. As 29·78 was the correct mean height of the barometer for June 24, 1884, it follows that 29·60 was the correct mean height for June 21, 1769.

Now let us take June 16, 1772, and June 15, 1809, and we shall find the differences of transit, parallax, and declination agree with the difference of height of the barometer.

	Transit.	Parallax.	M. Dec.	S. Dec.	Differences.		Bar.
16/6/1772	13·27	57·19	17·18	23·20	6·2	40·38	29·80
15/6/1809	1·53	54·40	16·54	23·17	6·23	40·11	29·88
Difference	0·26	2·39	0·24	0·3	0·21	0·27	
	—1	—8			—3	+4	
				Difference +1			
28/6/85	13·14	54·0	16·45S	23·16N	6·31	40·1	29·88
15/6/1809	1·53	54·40	16·54	23·17	6·23	40·11	29·88
Difference	0·39	0·40	0·9	0·1	0·8	0·10	
	—2	+2			+1	—1	

The plus and minus value are equal, and the heights of the barometer are the same.

	Transit.	Parallax.	M. Dec.	S. Dec.	Differences.		Bar.
28/6/85	13·14	54·0	16·45S	23·16N	6·31	40·1	29·88
16/6/1772	13·27	57·19	17·18	23·20	6·2	40·38	29·80
Difference	0·13	3·19	0·33	0·4	0·29	0·37	
	+1	+10			+4	—5	
					Difference = —1		

The plus values exceed the minus values by ·08th difference in the height of the barometer.

	Transit.	Parallax.	M. Dec.	S. Dec.	Differences.		Bar.
	h. m.	° ′	° ′	° ′	° ′	° ′	
24/6/84	1·19	60·12	16·42N	23·24	6·42	40·6	29·78
16/6/1772	13·27	57·19	17·18	23·20	6·2	40·38	29·80
Difference	0·8	2·53			0·40	0·32	
	—1	—9			+6	—4	
24/6/84	1·19	60·12	16·42N	23·24	6·42	40·6	29·78
15/6/1809	1·53	54·40	16·54	23·17	6·23	40·11	29·88
Difference	0·34	5·32			0·19	0·5	
	+2	—16			+4		
	—16+4+2=	—10=difference	in barometric heights.				
22/6/1902	13·32	54·29	16·40S	23·27	6·47	40·7	29·99
16/6/1772	13·27	57·19	17·18	23·20	6·2	40·38	29·80
Difference	0·5	2·50	0·38	0·7	0·45	0·31	
		+9			+6	—4	
					Difference = 19		
22/6/2	13·32	54·29	16·40S	23·27	6·47	40·7	29·99
11/6/27	14·26	60·49	16·18	23·2	6·44	39·20	30·17
Difference	0·54	6·20	0·22	0·25	0·3	0·47	
	—2	+19			+1		
22/6/1902	13·32	54·29	16·40S	23·27	6·47	40·7	29·99
24/6/1884	1·19	60·12	16·42S	23·24	6·42	40·6	29·78
Difference	0·13	5·43	0·2	0·3	0·5	0·1	
	—½	+17			+½		

The height of the barometer, therefore, on June 22 next, will be about 29·99.

By a similar process to that described for June 22, I find the height of the barometer for London for the other days as may be seen below.

	Bar.	
June 22, 1902.	29·99	Overcast in the morning, fine, with variable amount of clouds till evening; cloudless at night.
„ 23, „	30·03	Overcast, with slight shower in the morning or evening; fine and partially cloudy during the day, variable at night.
„ 24, „	30·09	Very fine during the morning, fine and partially cloudy afterwards; a pleasant day, but slightly unsettled in the evening.
„ 25, „	30·05	Cloudy and unsettled, with a few drops of rain during the morning, but fine, with some flying clouds afterwards.
„ 26, „	29·99	Generally cloudy in the morning, with slight rain; fine and partially cloudy till evening, then overcast for a time, with some rain.
„ 27, „	30·03	Misty and hazy in the morning; fine, with some flying clouds; not so warm.
„ 28, „	29·92	Very fine, bright, and warm day.
„ 29, „	29·84	Fine and generally cloudy; evening unsettled and sultry.
„ 30, „	29·80	Very fine, bright; partially cloudy, hazy and sultry.

On comparison I find that there is a great similarity between my calculated barometric curve from June 22 to the end of the month and those for 1772 and 1884, the former six days earlier, and the latter two days later in the month, and there is also a striking resemblance to the 1769 curve two days earlier in the month.

On June 23 there will be a slight fall in the barometer, the weather on that date being like that of the corresponding days in 1772 and 1884, with slight unsettlement different to the larger drop in the barometer and wet day in 1769. On June 25, 1902, the barometer will go up as it did in 1769, 1772, and 1884, but, on the 26th, the day appointed for the Coronation, there will be a drop in the barometer as there was on those three years, the day in 1769 being wet as the

barometric drop was large, but in 1772 and 1884 there was not much rain as the fall was much slighter. From June 27 to the end of month the barometer will be very steady, excepting a very slight fall of the barometer on the 29th that will not be sufficient to materially change the settled character of the weather.

The best days, therefore, for the Royal Coronation and the Coronation Procession would be the 27th and 28th instead of the 26th and 27th.

	Transit.	Parallax.	M. Dec.	S. Dec.	Differences.		Bar.
	h. m.	′ ″	° ′	° ′	° ′	° ′	
22/6/1902	13·32	54·29	16·40	23·27	6·47	40·7	29·99
26/6/1827	1·37	54·19	15·50	23·21	7·31	39·11	30·08 (30·00)
18/6/1901	1·53	58·31	16·55	23·24	6·29	40·19	29·89 (29·99)
24/6/1884	1·19	60·12	16·42	23·24	6·42	40·6	29·78 (29·97)
11/6/1827	14·26	60·49	16·18	23·2	6·44	39·20	30·17 (29·99)
16/6/1772	13·27	57·19	17·18	23·20	6·2	40·38	29·80 (29·99)

From the transit, parallax, and lunar and solar declinations of the above days, in the above years, the height of the barometer for June 22, 1902, is found to be very approximatively 29·99.

The height of the barometer in parentheses is that calculated from the actual height given immediately before it for the given day in the given year.

	Transit.	Parallax.	M. Dec.	S. Dec.	Differences.		Bar.
	h. m.	′ ″	° ′	° ′	° ′	° ′	
23/6/1902	14·19	54·49	14·7	23·27	9·20	37·34	30·03
22/6/1769	14·54	55·47	11·55	23·27	11·32	35·22	29·70 (30·03)
21/6/1769	14·8	55·17	16·42	23·27	6·45	40·9	29·60 (30·03)
25/6/1884	2·16	59·25	13·52	23·22	9·30	37·14	29·88 (30·03)
17/6/1772	14·18	56·25	15·2	23·20	8·18	38·22	29·80 (30·03)
16/6/1809	2·39	55·2	14·30	23·20	8·50	37·50	29·95 (30·03)

	Transit.	Parallax.	M. Dec.	S. Dec.	Differences.		Bar.
	h. m.	′ ″	° ′	° ′	° ′	° ′	
24/6/1902	15·5	55·17	10·54S	23·26	12·32	34·20	30·09
13/6/1884	16·8	56·9	9·32S	23·15	13·43	32·47	30·07 (30·09)
11/7/1884	14·54	56·33	7·2S	22·2	15·0	29·4	29·61 (30·09)
26/6/1884	3·10	58·29	10·15N	23·21	13·6	33·36	29·98 (30·09)
16/6/1900	15·32	58·56	11·10S	23·20	12·10	34·30	29·93 (30·09)

	Transit.	Parallax.	M. Dec.	S. Dec.	Differences.		Bar.
	h. 5m.	′ ″	° ′	° ′	° ′	° ′	
25/6/1902	15·01	55·50	7·4	23·25	16·21	30·29	30·05
27/6/1884	4·3	57·34	6·10	23·18	17·8	29·28	29·98 (30·05)
19/6/1772	15·3	55·18	8·27	23·25	14·58	31·52	29·95 (30·05)

	Transit.	Parallax.	M. Dec.	S. Dec.	Differences.		Bar.	
	h. m.	′ ″	° ′	° ′	° ′	° ′		
26/6/1902	16·35	56·28	2·55	23·23	20·28	26·18	29·99	
19/6/1809	4·57	56·51	3·20	23·26	20·6	26·46	29·90	(29·99)
14/6/1827	17·27	58·50	3·36	23·18	19·42	26·54	29·90	(29·99)
1/7/1827	5·43	57·5	3·50	23·9	19·19	26·59	29·78	(29·99)
15/6/1884	17·43	57·37	1·19	23·21	22·2	24·40	30·08	(29·99)
28/6/1884	4·37	56·9	1·57	23·16	21·19	25·13	30·02	(29·99)
8/6/1901	17·27	58·12	3·36	22·48	19·12	26·24	29·93	(29·99)
15/7/1900	15·10	59·58	2·29	21·34	19·5	24·3	29·95	(29·99)

	Transit.	Parallax.	M. Dec.	S. Dec.	Differences.		Bar.	
	h. m.	′ ″	° ′	° ′	° ′	° ′		
27/6/1902	17·23	57·9	1·31	23·21	21·50	24·52	30·03	
21/6/1772	17·19	54·36	0·38	23·27	22·49	24·5	29·80	(30·03)
20/6/1809	5·44	57·38	1·6	23·26	22·20	24·32	30·03	(30·03)
30/6/1827	4·37	56·20	0·27	23·13	22·46	23·40	29·80	(30·03)
12/6/1883	6·5	54·35	0·42	23·8	22·26	23·50	30·13	(30·03)
15/6/1884	17·43	57·37	1·19	23·21	22·2	24·40	30·08	(30·03)
4/7/1885	17·45	56·38	3·0	22·51	19·51	25·51	30·03	(30·03)
15/6/1899	5·27	54·39	0·28	23·19	22·51	23·47	29·94	(30·03)
5/6/1900	6·19	54·14	0·42	22·33	21·51	23·15	29·80	(30·03)

	Transit.	Parallax.	M. Dec.	S. Dec.	Differences.		Bar.	
	h. m.	′ ″	° ′	° ′	° ′	° ′		
28/6/1902	18·12	58·2	5·58	23·19	17·21	29·17	29·92	
26/6/1769	17·58	58·28	8·4	23·23	15·19	31·37	29·80	(29·92)
23/6/1772	18·43	54·29	7·10	23·27	16·17	30·37	29·80	(29·92)
2/7/1827	6·11	57·57	8·17	23·0	14·43	31·17	29·86	(29·92)
17/6/1884	19·23	59·12	7·38	23·25	15·47	31·3	29·99	(29·92)
30/6/1884	6·18	55·8	6·16	23·8	16·52	29·24	29·93	(29·92)
14/6/1899	4·47	54·19	5·25	23·17	17·52	28·42	29·91	(29·92)
17/6/1900	16·24	59·18	6·0	23·23	17·23	29·23	29·90	(29·92)
19/6/1900	18·5	59·17	5·0	23·26	18·26	28·26	29·74	(29·92)
8/7/1883	3·16	55·34	5·26	22·32	17·6	27·58	27·71	(29·92)
5/7/1885	18·32	57·30	7·7	22·45	15·38	29·52	30·04	(29·92)

	Transit.	Parallax.	M. Dec.	S. Dec.	Differences.		Bar.	
	h. m.	′ ″	° ′	° ′	° ′	° ′		
29/6/1902	19·3	58·52	10·17	23·17	13·0	33·34	29·84	
26/6/1769	17·58	58·28	8·9	23·28	15·19	31·37	29·80	(29·85)
27/6/1769	18·49	59·13	12·34	23·21	10·47	35·55	29·85	(29·85)
24/6/1772	19·27	55·0	11·30	23·24	11·54	34·54	29·80	(29·87)
17/6/1827	19·20	55·23	9·20	23·25	14·5	32·45	29·83	(28·88)
3/7/1827	7·2	58·48	12·20	22·56	10·36	35·16	29·93	(29·86)
15/7/1884	18·10	58·37	10·7	21·26	11·19	31·33	29·73	(29·85)
18/6/1884	20·17	59·59	11·46	23·26	11·40	35·12	30·03	(29·84)
1/7/1884	7·2	54·37	9·54	23·4	13·10	32·58	30·02	(29·84)
27/6/1898	6·16	57·31	9·56	23·19	13·23	33·15	29·65	(29·78)
30/6/1900	2·50	54·54	10·11	23·12	13·1	33·23	29·58	(29·81)
6/7/1885	19·23	58·26	11·0	22·39	11·39	33·39	30·05	(29·90)

	Transit.	Parallax.	M. Dec.	S. Dec.	Differences.		Bar.	
	h. m	′ ″	° ′	° ′				
30/6/1902	19·57	59·43	14·6	23·13	9·7	37·19	29·80	
27/6/1769	18·49	59·13	12·30	23·21	10·51	35·51	29·85	(29·80)
18/6/1827	20·9	55·4	13·3	23·24	10·21	36·27	29·85	(29·80)
2/7/1884	7·46	54·17	13·2	23·0	9·58	36·2	29·95	(29·80)
16/7/1884	19·4	54·29	13·45	21·16	7·31	35·1	29·[illegible]	(29·80)
22/6/1883	14·2	57·22	15·10	23·27	8·17	38·37	29·85	(29·80)
29/6/1883	20·4	59·32	14·29	23·14	8·45	37·43	29·81	(29·80)
16/6/1883	8·59	54·30	15·12	23·20	8·8	38·32	29·68	(29·80)

The following dates are compared in order to show how closely the differences in transit, parallax, and declination agree with the differences in barometric height:

	Transit.	Parallax.	M. Dec.	S. Dec.	Differences.		Bar.
	h. m.	′ ″	° ′	° ′	° ′	° ′	
24/6/1884	1·19	60·12	16·42	23·24	6·42	40·6	29·78
15/6/1809	1·53	54·40	16·54	23·17	6·23	40·11	29·88
	0·34	5·32			0·19	0·5	
	+2	−16			+3	−1	
					Difference 4		

Bar. Diff. = − 16 + 2 + 4 = 10.

28/6/1885	13·14	54·0	16·45	23·16	6·31	40·1	29·88
15/6/1809	1·53	54·40	16·54	23·17	6·23	40·11	29·88
	0·39	0·40			0·8	0·10	
	−2	+2			+1	−1	
		Diff. 0				Diff. 0	

Bar. Diff. = 0

18/6/1901	1·53	58·31	16·55	23·24	6·29	40·19	29·89
24/6/1884	1·19	60·12	16·42	23·24	6·42	40·6	29·78
	0·34	1·41			0·13	0·13	
	+2	+5			−2	+ 2	
						Diff. = 4	

Bar. Diff. = 2 + 5 + 2 + 2 = 11

24/6/1884	1·19	60·12	16·42	23·24	6·42	40·6	29·78
21/6/1769	14·8	55·17	16·42	23·27	6·45	40·9	29·60
	0·49	4·55			0·3	0·3	
	−2	−15			−½	+½	
						Diff. 1	

Bar. Diff. = − 2 − 15 − 1 = − 18

22/6/1769	14·54	55·47	11·55	23·27	11·32	35·22	29·70
16/6/1900	15·32	58·56	11·10	23·20	12·10	34·30	29·93
	0·38	3·9			0·38	0·52	
	1	10			−5	+ 7	
						Diff. 12	

Bar. Diff. 12 + 10 + 1 = ·23

22/6/1769	14·54	55·47	11·55	23·27	11·32	35·22	29·70
17/6/1809	3·25	55·31	11·24	23·25	12·1	34·49	29·81
	− 31	0·16			0·29	0·33	
						Diff. 9	

Bar. Diff. = 0 + 1 + 1 = ·11.

	Transit.	Parallax.	M. Dec.	S. Dec.	Differences.		Bar.
	h.m.	′ ″	° ′	° ′	° ′	° ′	
17/6/1809	3·25	55·31	11·24	23·25	12·1	34·49	29·81
16/6/1900	15·32	58·56	11·10	23·20	12·10	34·30	29·93
Difference	0·7	3·25			0·9	0·19	
	+1	+10			−1	+2	
					Diff. 3 or 1		

Bar. Diff. = 10 + 3 − 1 = 12 or 10 + 1 + 1 = 12

18/6/1772	15·7	55·53	12·18	23·24	11·6	35·42	29·80
17/6/1809	3·25	55·31	11·24	23·25	12·1	34·49	29·81
Difference	0·8	0·22			0·55	0·53	
		−1			−7	+7	
					0		

Bar. Diff. = ·01

19/6/1772	15·53	55·18	8·27	23·25	14·58	31·52	29·95
2/7/1885	16·14	55·13	5·4	23·1	17·57	28·5	30·01
Difference	0·21	0·5	3·23	0·24	2·59	3·47	
	+1	− 1			−24	+30	
					+6		

Bar. Diff. = ·06

27/6/84	4·0	57·34	6·10	23·18	17·8	29·28	29·98
2/7/1885	16·14	55·13	5·4	23·1	17·57	28·5	30·01
Difference	0·14	2·21	1·6	0·17	−49	1·23	
	0	−7			−7	+11	
					Diff. = + 4		

Bar. Diff. = − 7 + 4 = − ·03

23/6/1769	15·40	56·20	7·50	23·27	15·37	31·17	29·70
20/6/1883	15·44	58·18	7·22	23·25	16·3	30·47	29·77
Difference	0·4	1·58			0·26	0·30	
	+1	+6			−4	+4	
					Diff. 0		

Bar. Diff. = 1 − 6 = ·07.

19/6/1772	15·53	55·18	8·27	23·25	14·58	31·52	29·95
24/6/1883	15·44	58·18	7·22	23·25	16·3	30·47	29·77
Difference	0·9	3·0			1·5	1·5	
		+9			−9	+9	

Bar. Diff. = 9 + 9 = ·18

11/7/1884	14·54	56·33	7·2	22·2	15·0	29·4	29·61
10/6/1883	4·38	55·38	7·36	22·59	15·23	30·35	29·79
Difference	1·44	0·55	0·34	0·57	0·23	1·31	
	−3	−3			−3	−12	

Bar. Diff. = − 12 − 3 − 3 = − 18

19/6/1772	15·53	55·18	8·27	23·25	14·58	31·52	29·95
10/6/1883	4·38	55·38	7·36	22·59	15·23	30·35	29·79
Difference	0·45	0·20	0·51	0·26	0·25	1·17	
	2	+ 1			−3	+10	

Bar. Diff. = 16.

27/6/1884	4·0	57·34	6·10	23·18	17·8	29·28	29·98
24/6/1883	15·44	58·18	7·22	23·25	16·3	30·47	29·77
Difference	0·16	0·44	1·12	0·7	1·5	1·19	
	1	−2			+9	−11	

Bar. Diff. = 21.

	Transit.	Parallax.	M. Dec.	S. Dec.	Differences.		Bar.
	h.m.	′ ″	° ′	° ′	° ′	° ′	
14/6/1884	16·55	56·51	5·35	23·18	17·43	28·53	30·08
24/6/1883	15·44	58·18	7·22	23·25	16·3	30·47	29·77
Difference	1·11	1·27	1·47	0·7	1·40	1·54	
	−2	+4			+14	−15	

Bar. Diff. = 31

24/6/1769	16·25	57·0	2·55S	23·26N	20·31	26·21	29·55
4/7/1885	17·45	56·38	3·0N	22·51N	19·51	25·51	30·03
Difference	1·20	0·22	5·55	0·35	6·30	5·20	
	−3	−1			+52	−43	

Bar. Diff. = 52 − 3 − 1 = 48 or − 43 − 3 − 1 = − 47

24/6/1769	16·25	57·0	2·55S	23·26N	20·31	26·21	29·55
13/7/1884	16·29	57·42	1·32N	21·45	20·13	23·17	29·71
Difference	0·4	0·42			0·18	3·4	
		+2			+3	+25	

Bar. Diff. = $\frac{3 + 25}{2}$ + 2 = 16

18/6/1772	15·7	55·53	12·18	23·24	11·6	35·42	29·80
23/6/1898	3·22	54·45	11·51	23·26	11·35	35·17	29·77
Difference	0·15	1·8	0·27	0·2	0·29	0·25	
	+1	−3			−4	+3	
					−1		

Bar. Diff. = − 3

14/6/1884	16·55	56·51	5·35	23·18	17·43	28·53	30·08
27/6/1884	4·0	57·39	6·10	23·18	17·8	29·28	29·98
Difference	0·55	0·48	0·35	0·0	0·35	0·35	
	+2	−2			+5	−5	
					Diff. = 10		

Bar. Diff. = 10

In making the predictions of the weather for the last nine days of June, 1902, I have taken care first to take days in those years in which there was a similarity in the time of transit or meridian-passage of the moon, the amount of moon's parallax, and closeness in the declination of the moon and sun. Secondly, I have used the average daily heights of the barometer as recorded at the Greenwich Observatory, and when these were not available, I have checked their accuracy as compared with those taken at Greenwich; and thirdly, I have from these, in past days, making allowances for the differences in transit, parallax and declination, calculated the height of the barometer for each of the last nine days of June next, and from the barometric curve thus obtained I have made a prediction of the weather, based upon those days in the past in which the difference of transit, parallax and declination were at a minimum. The difference in transit, parallax, and declination between any two days is an exact measure of the differences in the heights of the barometer for those two days.

April 1902. HUGH CLEMENTS.

II

SAMPLES OF WEATHER PREDICTIONS—AND VERIFICATIONS.

From a great mass of evidential material the examples which follow have been taken as being fairly representative of the whole. The author leaves this evidence without note or comment; in such a situation the members of the jury, that is to say the general public, are capable of judging of the value of the evidence without accompanying argument or pleading of any kind.

(1) METEOROLOGICAL OFFICE AND CLEMENTS COMPARED WITH GREENWICH FOR FEBRUARY 189[illegible]

	Meteorological Office.	*Greenwich Record.*	*Clements.*
1.	Fair generally, but snow or sleet showers in places.	Variable in M, very fine 7 to noon, overcast after, and rain between 4 p.m. to 7 p.m.	Early M rain, fine after, slightly cloudy, E foggy.
2.	Changeable, some rain.	Overcast generally.	M hoar-frost, fine and partially cloudy.
3.	Showery.	Overcast and showery in M, very fine afterwards.	Fair and slightly cloudy, overcast at night.
4.	Fine weather, then rain.	Very fine, cloudy afternoon, variable clouds at night.	Hoar frost M, cloudy and foggy, afterwards very fine and cloudless.
5.	Fair to cloudy, some rain.	Overcast generally, showery forenoon, heavy rain.	Fine, partially cloudy till afternoon overcast afterwards.
6.	Fine, showery later.	Overcast	Fine and slightly cloudy.
7.	Showery, at times bright, intervals drier air.	Overcast, slight rain at night.	Foggy, cloudy till afternoon, clear after.
8.	Clearing, not settled.	Variable M, general cloudless day, very fine.	M hoar frost and fog, afterwards fine and cloudless.
9.	Some showers.	Fine early M, overcast till E, rain between 2 p.m. and 3 p.m., fine at night.	Hoar frost, overcast, with occasional rain in E.
10.	Fine, doubtful later.	Fine, partially cloudy.	Fine and partially cloudy.
11.	Rain, very unsettled.	Overcast, occasional rain.	Overcast till afternoon, E fine and cloudy.
12.	Hail or sleet showers, very unsettled.	Showery, cloudy M, after very fine.	M overcast and unsettled till 9 a.m., slightly cloudy till 4 p.m., afterwards cloudless.
13.	Some cold showers.	Fine.	Hoar frost, fine and cloudy, slight shower in E.
14.	Local fogs, unsettled, some rain	Variable, cloudy, overcast after 10 p.m., slight fog prevailed throughout.	Early M rain, afterwards fine and partly cloudy.

15.	Unsettled, some rain.	Overcast and showery til E, variable at N.	Generally cloudy, with occasional slight rain.
16.	Changeable, some rain.	Overcast generally.	Overcast, with occasional slight rain.
17.	Dull, misty, some rain.	Overcast, rain nearly all day.	Overcast, slight rain or snow.
18.	Dull, with snow or sleet, improving later.	Very fine, slightly cloudy.	Overcast, very slight rain or snow.
19.	Fine.	Very fine, cloudless throughout.	Partially cloudy and unsettled.
20.	Fine and dry.	Hoar-frost, very fine, a few light clouds.	Hoar-frost and slight fog, fine and partially cloudy till afternoon, cloudless night.
21.	Fine, foggy inland	Hoar-frost, generally cloudless, fine, slight fog.	Very foggy, hoar-frost and slightly unsettled.
22.	Fine, fog locally.	Hoar-frost, fine and partially cloudy overcast at night.	M foggy, frosty and slightly unsettled, fine, partially cloudy, cloudless at N, with occasional fog.
23.	Fine, tending to rain.	Slight hoar-frost, cloudless 5 a.m. to 11 a.m., generally cloudy after, rain after 10 p.m.	M frosty, fine and cloudy till afternoon overcast and unsettled from 6.30 to 10 p.m.
24.	Rain, finer later.	Overcast in M, rain till 5 a.m., fine and partially cloudy till E, cloudless at night.	Fine and partially cloudy, overcast and unsettled at night.
25.	Fog, then clearer; unsettled later.	Overcast generally, rain fell between noon and 2 p.m.	Overcast, with occasional rain till afternoon, fine and variable, cloudy after.
26.	Very changeable, unsettled, some rain.	Overcast generally.	Overcast, with occasional rain to fine.
27.	Rain at first, finer later.	Overcast, set rain between 1 a.m. and noon, fine afterwards.	Overcast to cloudy and unsettled.
28.	Fine at first, unsettled later, some rain.	Overcast, with rain in M, gloomy at noon, cloudy till E.	M fine and bright, afternoon overcast and slightly unsettled.

(2) December Weather, 1896

In the accompanying barometric curves the upper is my prediction and the lower is the actual record. As predicted, the barometer went down on the 1st, 2nd, 3rd, reaching its lowest point on the 4th, went up on the 5th, and down to a low point on the 6th, as indicated. The barometer rose rapidly on the 7th, and, with slight fluctuations, reached its highest point late on 9th and early on 10th. It descended slightly, as represented, on the 10th and rose on 11th, went down somewhat on 12th after being high in the morning went up again so as to be high on the morning of the 13th as represented, and immediately descended on the 13th, afterwards reaching a low point on 14th; it

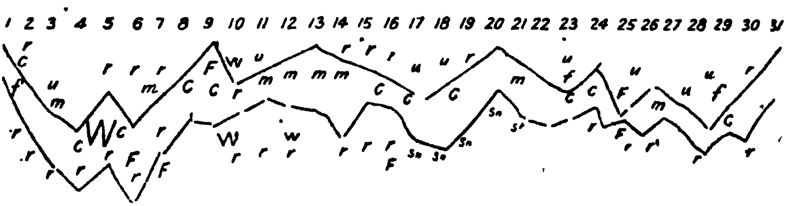


Fig. 72.

fluctuated, going up and down on 15th and 16th, reaching its lowest point late on 17th and early on 18th, as shown on curve, going up on 18th and 19th, reaching its highest point on the 20th exactly as predicted and indicated on both curves. The barometer then descended on 21st and 22nd, reaching its lowest position on 23rd, in the morning rose immediately, reaching its highest position as represented on the 24th, going down lower late on 24th and morning of 25th, going up same day, and being high at end of day, and morning of 26th was high again as indicated. The barometer went down on 26th later in day, and both up and down on the 27th, reaching the lowest point as indicated on the diagram on 28th; then there was an oscillation on 29th and 30th, with a final rise as shown on

31st, which rise, as represented in my January curve, continued on New Year's Day, and on the 2nd and the 3rd reaching its highest point was going down.

I maintain that this predicted curve gives an almost perfect representation of the movements of the air-pressure over London for last month with a very close connexion between the rain and other phenomena predicted and that recorded.

January 1897. HUGH CLEMENTS.

(3) ACCURATE SCIENTIFIC WEATHER PREDICTIONS POSSIBLE

The upper barometric curve is my predicted curve for London, and the lower is the actual curve from March 1,

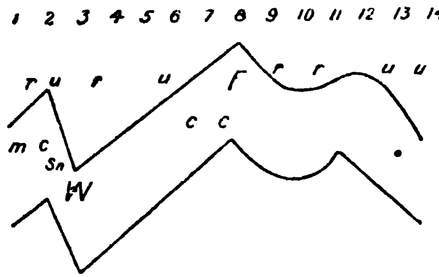


FIG. 73.

1897, up to date. This curve is correct. The *r* denoting rain and the *u* unsettled, with no rain on 5th, 7th and 8th, is correct for London. The *c* denoting cold breaks comes out correct, and the F for the foggy day of 8th is also correct. The great gale is accurately predicted for the 3rd, when there was the enormous pressure of 26 lbs., and on the 2nd and 4th with 17 lbs. and 20 lbs. pressure respectively. The predicted curve and the predicted weather are almost exact facsimiles of the actual. It is impossible to make predictions with more accuracy. This is part of my prediction from December to end of March, 1897, sent to the Press and British Museum on November 26, 1896. From December 1, 1896, to March 14, 1897 (up to date) every day has been

likewise correctly predicted. The chances against the 1st of March, the 91st successive day, being right was 1,000,000,000 000,000,000,000,000,000 to 1, and March 14, the 104th day, being right was 16,000,000,000,000,000,000,000,000,000,000 to unity, i.e., sixteen billion trillions. The chances against December 1, the first day predicted, were even, for on tossing a disc the chances are even against the wrong or right side turning up. The chances against both right sides of two discs tossed up are two to one; of three discs four to one; four discs eight to one; five discs sixteen to one; six discs thirty-two to one; thirty-one discs 1,000,000,000 to one; sixty-two discs tossed up for December 1896 and January 1897, the chances are four trillions to one; and ninety discs for December, January and February, the chances against my being right were one thousand million trillions. The truth of the matter is, I can predict the weather for any number of days, weeks, months, or years ahead upon a scientific system, from which the element of chance is eliminated.

March 15, 1897. HUGH CLEMENTS.

(4) MY WEATHER PREDICTIONS

It is generally acknowledged that if the changes in the air-pressure for any given place, as indicated by the barometer, could be predicted, that the weather dependent thereupon could also be predicted.

In proof of this statement I give on the accompanying sheet[1] the curve which I predicted from December 1, 1896, to March 31, 1897, and which was sent to the British Press and the British Museum in November, 1896. Underneath I give the mean daily barometric curve as recorded at the Greenwich

[1] I quote this and similar documents, although they repeat facts previously narrated, because they are authentic statements made when the circumstances were fresh and details present to the minds of any and all interested.

Observatory. The predicted and actual curves are so similar for the 121 days referred to that I claim to have made an almost accurate prediction; and if the various weather-factors as indicated by *r* for rain, *u* for unsettled, *c* for cold, *m* for mild, *f* for frost, F for fog, *sn* for snow and W for wind, are taken into account, I claim to have predicted the general weather for December, January, February, and March, dependent upon that curve. The general accuracy is continued up to April 4, when I wrote, thus giving a generally correct forecast of the weather for London for 125 consecutive days, the chances against every one of the 125 days being right being thirty-two trillions of trillions, or 32,000,000,000, 000,000,000,000,000,000,000,000,000, to unity, i.e., if 125 discs were tossed up all the right sides would not turn up more than once in thirty-two trillion trillion tosses.

I issued separate statements for December 1896, January and February 1897, which were sent to the Press and the British Museum, pointing out the accuracy of my predictions.

For March I predicted frequent precipitation during the first half of the month, and there was more or less rain on fourteen out of the first eighteen days; I also predicted heavy rain for the end of the month, and the rain fell, there being an interval of twelve days, from 18th to 31st, with generally fine weather, in accordance with my prediction.

The air-pressure was highest about March 19 as I predicted, actually highest near midnight or soon after on that day at London.

The air-pressure for London and England was under the average as I predicted, and the predicted curve from beginning to end of the month was almost a facsimile of the actual curve. Anyone who carefully examines my predictions cannot but observe that the changes of temperature, the wind, and other phenomena, were correctly predicted.

April 1897. HUGH CLEMENTS.

(5) Winter Weather, 1898

The accompanying curve (see fig. 74) indicates what the movements of air-pressure in London will be from January 1 to March 31, 1898, as will be registered by the barometer.

As shown, the curve will range between 28·75 and 30·25 inches, and from the dates marked over the curve the approximate height of the barometer for any given day may be found.

The letters *w* denote wind, *r* rain, *u* unsettled, *sn* snow, *sl* sleet, *o* overcast, F fog and *f* frost, *hl*, hail, *l* lightning, and *t* thunder.

I have already issued a curve showing what the minimum temperatures for London will probably be.

The weather for each day can be made out by the reader, as the curve, with the reference-letters, is self-explanatory.

Hugh Clements.

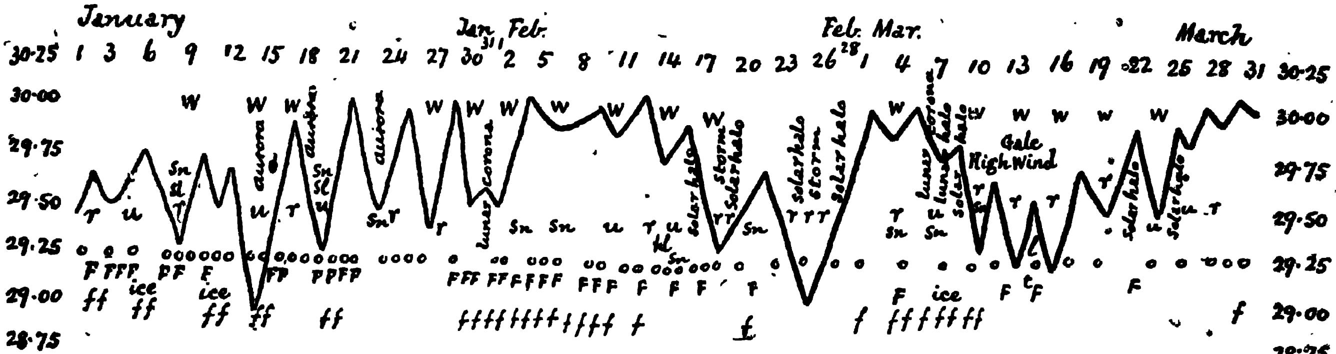
(6) A Month's Minimum TEMPERATURE Curve—Anticipation and Actuality

On September 18 last I predicted the minimum temperatures in October, for London.

On comparing the predicted and the actual curves, there was found to be a very striking resemblance.

I have proved that it is possible to predict very approximately the height and movements of the barometer; the above predicted curve proves that temperature also may be approximately predicted.

Hugh Clements.



BAROMETRICAL PREDICTIONS, 1893.

FIG. 74.

(7) VERIFICATION OF DECEMBER WEATHER FORECAST 1898

On November 26 last I predicted that the thick curve would represent the movements of the barometer in London for December 1898. The thin curve gives the movements recorded at Greenwich Observatory, and a comparison of the similarly lettered curves the comparative accuracy of my predicted curve. Except on December 29, when the barometer fell to 29·00, the range agreed with that predicted between 29·50 and 30·25. The barometer was actually higher from 10th to 25th, than I predicted from 8th to 22nd, but it was during this fortnight, as predicted, that most of the fine weather occurred. It was predicted

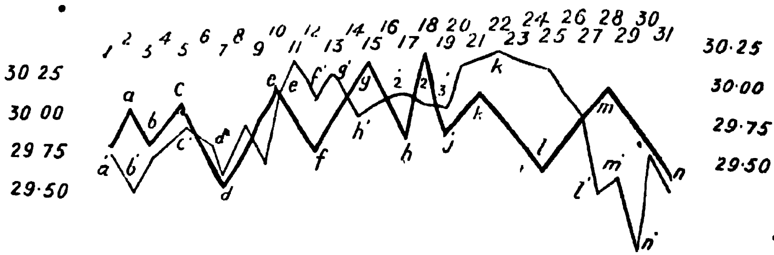


FIG. 75.

that there would be some unsettlement round the 12th, 17th, and 19th, and these days were overcast and unsettled with tendency to rain, and from the 15th to the 21st it was generally overcast as I predicted. Excepting some rain on the morning of the 9th, it was fine from 8th to 11th, and on the 13th and 22nd as predicted.

From the 1st to the 7th I predicted it would be of an unsettled rainy character, and it rained just before the 1st and on the 2nd, on the 3rd, 4th, and 6th, and terminated on the 7th as predicted, with 1·20 inches of rain.

The 24th was overcast, the 25th was overcast in the morning though very fine afterwards, the 26th was generally overcast and unsettled, the 27th was overcast with continuous

rain and a gale of wind, the early morning of the 28th was wet, the 29th was overcast with frequent rain; there was rain on early morning of the 30th, and there was frequent rain on the 31st.

My prediction, therefore, of an unsettled period from 24th to the end of the month, with more or less rain, especially round the 26th and 30th, was amply fulfilled.

There was a brisk wind on the 6th, 19th, and 26th, and on the 27th there was a gale, and on the 29th, 30th, and 31st there was a brisk, and at times on the 30th, a gusty, wind. My prediction that there would be wind on 6th or 7th, round the 18th, 24th and 31st, was approximately accurate.

Generally speaking, the worst weather occurred at the

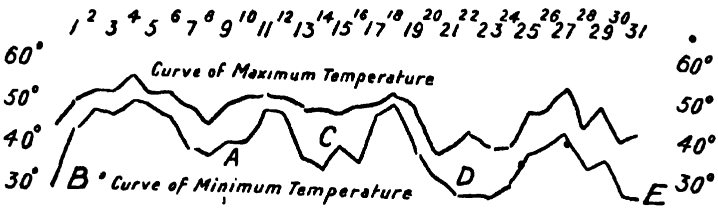


FIG. 76.

beginning and end of the month as I predicted, and on and after the 8th there was a fortnight of better weather, as predicted.

The above curves give the maximum and minimum temperatures as recorded at the Greenwich Observatory for December 1898.

December was on the whole a mild month, as I predicted. Taking the full month it was 6° above the average. There were breaks of colder weather as I predicted at the beginning and end of the month. Please note the low temperatures at B and E, the beginning and end of curve.

And, as predicted, there were also breaks of colder weather round the 10th, 15th, and 21st, as indicated at A, C, and D, marked on the curves.

HUGH CLEMENTS.

(8) VERIFICATION OF MY PREDICTIONS FOR SUMMER 1900

On May 13th last I predicted that this summer would be a remarkably fine one, and that the cold, unsettled and showery weather would gradually improve and become finer and drier, culminating in a great drought during the month of July, which would gradually abate during August.

Excepting June 21st and 25th and July 2, when the humidity of the atmosphere at London was great, the drought continued to increase from June 17 to July 16, from which

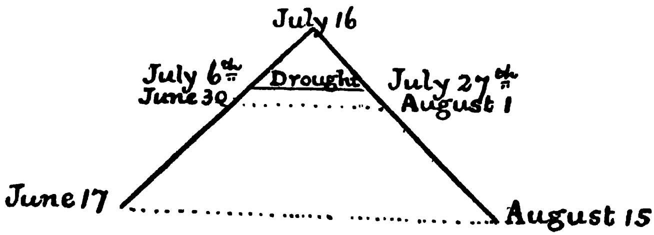


FIG. 77.

date it will decrease till August 15. From July 6 to July 27th, during three weeks, there was absolute drought in London, the apex of drought being reached on July 16, when the temperature 94° was the highest for the month and the humidity of the air was only 61 per cent. and approaching 55, the lowest, excepting 50 on July 10, when the hot weather was inaugurated.

August 1902. HUGH CLEMENTS.

(9) VERIFICATION OF MY PREDICTIONS FOR NOVEMBER 1900

In my prediction for November, made on October 27, 1899 I stated that (*a*) the *barometer would attain no very great height*, and up to date the highest point reached was 30·03 in.; on the 2nd and 3rd it went down; on the 4th, and since then, excepting on the 8th, 11th, 15th, 19th and 20th, it has been under 29·70 in.

On the 6th and 7th the barometer was under 29·40 in.; on the 9th and 10th it was just over 29·50 in.; it was low from the 13th to the 16th, when it went down to 29·10 in., and it has been rather low from the 21st up to date.

I stated that (*b*) *the weather would be of a generally unsettled character*, and up to date there has been rain on eighteen out of twenty-seven days, and there has been remarkably little sunshine. (*c*) There was windy weather from 6th to 9th, and 17th to 20th as predicted. I predicted that (*d*) *the maximum temperature would not often exceed* 60° *nor fall below* 40°, and so far there has been only one day, the 1st, when the temperature reached 62°, and on no day has the maximum been lower than 40°.

HUGH CLEMENTS.

(10) THE GREAT WEATHER MISTAKE OF THE GREENWICH OBSERVERS

In the accompanying illustration the line from M to M is

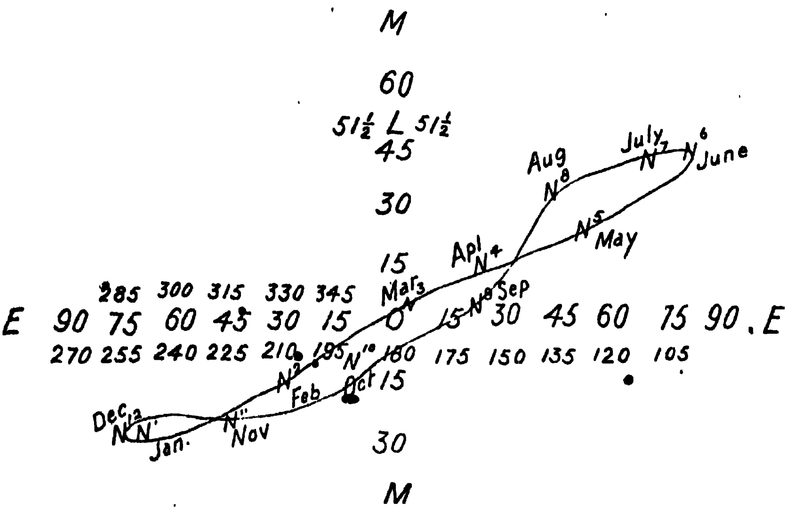


FIG. 78.

taken to indicate the meridian of Greenwich, and the line from E to E at right angles thereto represents the equi-

noctial line marked from 360° (0°) to 90° on the right back to 180° on the anti-meridian and thence to 270° and back to 360° or 0° the meridian of London. From 270° to 360° and from 0° to 90° will denote places on the same hemisphere, as London, and from 90° to 180° and on to 270° represents longitudes on the opposite hemisphere to that in which London, marked L in fig. 78 at $51\frac{1}{2}$° N. is placed.

The new moons from January (marked N^1) to June (N^6) took place in the year 1896 in the hemisphere of London, but those of July (N^7) and from Aug. to December 1896 (N^8 to N^{12}) took place in the nadir hemisphere.

The idea of the Greenwich observers, and of scientific men in general, was that, if the moon had any effect upon the weather it ought to be similar at the times of new moon. In 1896, and in fact in any other year, the position of the moon may, up to 90° from the meridian and anti-meridian of London, vary in longitude and in latitude from London.

Under these varying positions in angular distance from London in long. and lat., it is unreasonable to expect the weather to be the same or similar at each time of new moon. During 1896 half the new moons came in wet and half came in dry. During fifty years the Greenwich observers found also that half the new moons were wet and half dry, but as the position and conditions at every time of new moon are different, it was most unscientific for them to conclude that the moon had no appreciable effect upon the weather. Again at each new moon the distance of our attendant from London may be anything between 221,600 miles to 252,960 miles, and for the Greenwich observers to expect the same weather with a difference in distance of 31,360 miles at the time of new moon was to expect that which could not occur.

III

Rules for Weather Prediction

1. *How to calculate the Height of the Barometer for any future day, with Application to Tides and Earthquakes.*

(*a*) In order to predict the weather correctly for any given place, it is necessary to be able to predict the actual height of the barometer.

(*b*) In order to predict the daily height of the barometer for a month, a year, or several years in advance, it is necessary to have the mean daily heights for several years in advance.

(*c*) In calculating the height of the barometer for any day in the future it is essential to know the mean height for a corresponding day in the past, together with the times of the moon's transit, the moon's parallax, and the declinations of the moon and sun for the past as well as the predicted day. The parallax of the sun, varying only from 9·90″ to 8·70″, may be neglected so far as its influence upon the barometer is concerned.

(*d*) The moon's transit or time of meridian passage fixes with great exactitude the relative longitudinal separation of the moon and sun from 0° to 180°, or from 0 hour to 12 hours. The height of the barometer at any given place depends upon the degree of separation, other conditions being similar.

(*e*) The horizontal parallax, or the angle subtended by the equatorial radius of the earth at the distance of the moon, enables us to estimate exactly the effect of the varying distances of the moon upon the height of the barometer.

(*f*) And with regard to the moon's declination (and the same may be said of the sun's) all other things being equal, the effect of the moon, so far as the barometer is concerned, is the same when the declination north of the equator is equal to the declination south of the equator.

(*g*) The effect on the barometer is the same (other things being equal) whenever the moon passes the meridian at equal intervals of time before or after noon or midnight, and 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 and 11 hours' intervals are respectively

equal in effect to 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22 and 23 hours.

2. To Find the Equivalent in Barometric Height of 1′ of Parallax.

I have here put together for comparison the figures giving the position of moon with the sun's declination, and the corresponding height of the barometer at Greenwich for February 10, 1883, and April 29, 1882.

	Transit.	Parallax.	M. Dec.	S. Dec.	Diff.	Bar.
	h.m.	′ ″	° ′	° ′	° ′	
10/2/83	2·37	60·25	4·0N	14·28S	18·28	29·27
29/4/82	9·21	54·35	4·0S	14·20N	18·20	29·09

With regard to the transit, it will be noticed that the interval in time after noon is practically the same as the interval before midnight, and that taking the declinations north as equal to the south, all the factors are alike so far as their effect upon the barometer is concerned, excepting the parallax. The difference in parallax is 5′ 50″, which is equal to a difference in height of ·18 in. barometer, taking 5′ 50″ as practically 6′, we have 1′ of parallax as equal to barometric height of ·03.

When the moon is nearest the parallax is about 61′, and when farthest off is about 54′, the difference being 7′, which multiplied by ·03 gives ·21 in. as the difference in height of the barometer when the moon is nearest and furthest off, the other factors being equal.

3. To find the Equivalent in Barometric Height of 1° of Declination.

On May 13, 1901, the moon transited the meridian at the same time as on May 31, 1883, when the parallax was

	Transit.	Parallax.	M. Dec.		S. Dec.		Diff.	Bar.
	h.m.	′ ″	° ′		° ′		° ′	
13/5/01	20·22	59·55	3·21N		18·17N		14·56	33·19
31/5/83	20·22	60·2	8·57N		21·55N		12·58	30·03
	Difference		5·36	—	3·38	=	1·58	0·16

practically the same. In two cases we found that the difference in the declinations of the moon is greater than the difference in the sun's declinations, and that this difference

of 1°58′ also equals the difference between the differences of the declinations of the moon and sun. And this difference of 1°58′ or practically 2° is equal to a barometric difference of ·16 in., or 1°, is equal to ·08 bar.

4. *To find the Equivalent in barometric height of one hour's difference in time of transit.*

Now having found the barometric value for 1° of declination to be ·08, and for 1′ of parallax to be ·03, we substitute these

	Transit.	Parallax.	M. Dec.	S. Dec.	Diff.	Bar.
	h.m.	′ ″	° ′	° ′	° ′	
20/8/01	4·33	54·14	15·11S	12·36N	2·35	30·24
21/1/99	8·18	54·44	22·40N	19·52S	2·48	30·13
Difference	3·45	0·30	7·29	7·16	0·13	0·11
Value	0·075	0·015			0·02	

values for the differences in declination and parallax for the days of August 20, 1901, and January 21, 1899. The 13′ difference in Dec., about the fourth of a degree, is equal to the fourth of ·08 or ·02 Bar., and the 30″ parallax is equal to the half of ·03 or ·015 Bar. Adding ·015 and ·02 we obtain ·035, which deducted from ·11 Bar. leaves ·075 Bar. as the value of a difference of 3 hours and 45 minutes difference in transit, or 1 hour difference in transit, is equal to ·02 Bar.

We can now, by substituting these values for the differences in transit, parallax and declination between any two days, find the height of the barometer for one of the days when the other is given.

5. *How to Calculate the Height of the Barometer and, inferentially, to Predict Tides and Earthquakes.*

In November 1901 I calculated the daily height of the barometer for London for the month of December, 1901.

For December 1, 1901, I had only the moon's transit, parallax and the delination of sun and moon as here given, in

	Transit.	Parallax.	M. Dec.	S. Dec.	Diff.
	h.m.	′ ″	° ′	° ′	° ′
1/12/01	17·25	56·38	6·20N	21·44S	15·24

order to find the height of the barometer for that day. Having the times of transits of the moon for all the past years, let us select a day when the transit was either the same or nearly the same at twelve hours' difference. We will take

first of all November 25, 1884, when the time of transit was nearly the same at twelve hours' interval, viz., 5·50, the difference being 0·25 minutes, which is almost equal to ·01 Bar.; and the parallax 56·0 is nearly the same, being 0·38 less, which is equal to ·02 Bar. Next, we find that the moon's declination was 7·41, and we take year 1884 because then the nodal position was much the same as during 1901; as November 25 was only six days before December 1, there is not much difference between the sun's declination on those days. We find the differences on those days to be

Transit.	Parallax.	M. Dec.	S. Dec.	Diff.
h.m.	° ′	° ′	° ′	° ′
0·25	0·38	1·21	0·51	0·30

and their value to be

0·01	0·02			·04

and having these values for the differences, and as the differences between the declinations of the moon and sun for December 1, 1901, was greater than the corresponding difference on November 25, 1884, the ·04 has to be added to the ·02 and ·01 deducted, leaving a plus difference of ·05, which, added to the height of the barometer for November 25, 1884, viz., 30·08, gives 30·13, which was the exact height of the barometer at Greenwich on December 1, 1901.

In this instance the weather for December 1 should be the same very approximately as on November 25, 1884. Again, if we take December 11, 1900, we shall find the difference to be

	Transit.	Parallax.	M. Dec.	S. Dec.	Sum.
	h.m.	′ ″	° ′	° ′	° ′
	0·45	1·28	0·6	1·16	1·22
Value	0·01	0·04			0·11

and the sum of these differences 0·16, which, added to 29·97, the height of the barometer on December 11, 1900, gives us as before 30·13 as the height of the barometer on December 1, 1901.

Further, if we take December 8 or 9, 1899, or December 7 or 8, 1884, or November 24, 1899, or December 19, 1883, or November 24, 1883, we shall find that the difference of transit, parallax and declination in each case between those days and December 1, 1901, is exactly equal to the difference in height of the barometer.

IV

FORECASTING

As the records of 186 years ago are very generally incomplete, it is necessary, if reliable daily, weekly, or monthly, forecasts are to be made, to devise some method by which the weather-records of more recent years may be utilised. This I have attempted, with great success, to do in the following way:

> If we take the perigee and apogee, when they occur approximately with the new and full moon respectively, or *vice versa*, it is found that the interval between the phases and apses gradually increases up to a maximum of about seven days, and then diminishes to zero, and then back again from minimum to maximum.

These differences I have termed *apsidal differences.*

The connexion between these *apsidal differences* and the weather is both intimate and peculiar. Every sixty-two years, these *apsidal differences* are similar, if not practically identical.

Every thirty-one years they are also similar; and also at intervals of eighteen and thirteen years, at their difference, five and ten, twenty, thirty, years.

In this way we may forecast the weather of any given year, by taking a year five, ten, thirteen, eighteen, thirty-one, or sixty-two years before, whichever is found most suitable, taking the whole cycle into consideration.

In January 1895, for instance, the full moon occurred on the 10th, at eighteen hours forty-nine minutes astronomical time, or at forty-nine minutes past six on the morning of the 11th; and perigee took place exactly at midnight on 11th, so that about seventeen hours elapsed between the phase and the apse, in this case indicated by P F u, P denoting perigee, F full, and *u* shows that the time of the phase is *under* or before that of the apse.

Going back, we find the same condition of phase and apse in November 1893, when the full moon occurred on the 23rd, at 6 p.m., and perigee on 24th, at 2 p.m., denoted by P F u, twenty hours. In October 1892 there was the same condition denoted by P F u, twenty-three hours. In August 1891, P F u was twenty-four hours. In July 1890 P F u was twenty-five hours. In May 1889, and March 1888, P F u was the same; but in February 1889, December 1885, November 1884, the apsidal differences continue to increase, and the weather changes from wet to dry, as it always does as the apsidal differences decrease.

In March 1888, May 1889, July 1890, August 1891, and October 1892, it was wet, with a difference of about twenty-four hours; but as the differences continued to increase in February 1889, and December 1885, it was dry.

Thirteen years previous to January 1895, in January 1882, we had the phases and apses reversed, but the apsidal differences about the same in amount. In January 1882, the new moon occurred on 19th, at 4·35, and perigee at 20·1, with a difference of 0·20 hours; and the full moon at 2·18, and apogee, February 3·23, the apsidal differences being 1·5. The weather was dry.

In December 1876, and January 1877, the differences were 0·15 P F u, and 0·13 A N u, when it was wet.

In January 1864, thirty-one years earlier, the differences were 0·19 P N u, and 0·23 A F u, the weather being dry.

And in 1833 the differences were 0·18 P F u, and 0·23 A N the weather being dry.

Apsidal Differences

As a general rule it is quite easy to say whether certain months of the year will be wet or dry by the nature and the amount of the *apsidal difference*. The *apsidal difference* is the difference between the time of new or full moon and the time of apogee or perigee. For instance, in September 1891, full moon occurred at five o'clock on the morning of the 18th inst., and perigee on the same morning at seven o'clock, the difference, two hours, being termed the *apsidal difference*. This apsidal difference is fully described by the letters P F u, indicating that we are dealing with the difference between *P* perigee and *F* full moon, and the letter *u* denoting that the

time of the full moon is below or (u) under that of the time of perigee.

Now a year previously, viz., in the issue of the *Pall Mall Gazette* for October 1, 1890, I stated that September 1891 would be dry on account of the smallness of the apsidal difference. And the reason given for this was because I had always found, in past years, that, when the apsidal difference, denoted by P F u, is small, the month in which it occurs will be a dry month. A great many instances of this could be cited, but perhaps the most notable one is the succession of dry months year by year from 1833 to 1849, in which this particular difference was small. Thus in January 1833 the full moon took place at eight o'clock on the morning of the 6th, and perigee occurred the same day at four o'clock in the afternoon, the difference being eight hours (P F u). The same small difference occurred in February 1834; April 1835; May 1856; July 1837; September 1838; October 1839; December 1840; January 1842; March 1843; May 1844; June 1845; July 1846; September 1847; November 1848, and December 1849, and in each case there was very little rainfall.

Now there is another kind of small difference between the time of perigee and the time of new moon denoted by P N o (the *o* denoting that the time of the new moon is in advance or over that of the time of perigee), which also indicates dry weather. For instance, in February 1873 new moon took place on the morning of the 27th at three o'clock, and perigee occurred on the 26th at two o'clock in the afternoon, the difference being thirteen hours. This was a dry month, and so were March 1874; June 1875; July 1876; September 1877; October 1878; December 1879; February 1882; April 1883; May 1884; July 1885; August 1886; October 1887; December 1889; January 1890; and February 1891: these were all dry months, with a small interval of time between the time of new moon and the perigee just behind it. In 1895, April was dry for the like reason.

It will thus be seen that with a small difference between the time of perigee and the new or full moon, the month in which it occurs is dry.

The month is wet when there is a large difference. For instance, December 1833 was very wet, as the new moon

took place on the morning of the 11th at seven o'clock, and perigee occurred at ten o'clock at night on the 4th, the difference being six days and nine hours. August 1857; August 1866; November 1877; November 1886; February 1880, and February 1889, were all wet, there being a large difference between the time of perigee and the time of new moon. December 1847; January 1857; April 1859; May 1869; June 1860; July 1861; September 1871; January 1866, and January 1875, were also wet, with large differences. And further, January 1866; March 1876; May 1869; June 1878; August 1879; September 1891; September 1880; June 1878, and July 1888, were all very wet, the difference between the time of full moon and perigee being large.

Then January 1875; March 1876; April 1877; June 1878; August 1879, and September 1880 were very wet, with large differences.

And finally, March 1888; May 1889; July 1890, and August 1891, were very wet, there being a difference of twenty-five hours between the time of full moon and the time of perigee.

In the *Mark Lane Express* of January 1890, it was predicted that July of that year would be a wet month, and in the *Pall Mall Gazette* of October 1, 1890, that August 1891 would be a very wet month. There were also my predictions, founded upon these apsidal differences, for the whole of the months of 1890 and 1891, and they proved to be correct.

In the accompanying tabular statements, W denotes wet months and D dry months. W_1 represents from 100 to 110 per cent. of average rainfall; W_2 110 to 130, and so on till W_7 stands for 250 per cent. of average rainfall and above. Similarly, D_1 denotes from 100 to 75 per cent. of average, D_2, 75 to 50, until we come to D_7, standing for 10 per cent. of average rainfall and under.

In the first table, PNo denotes that the time of perigee took place earlier than the time of new moon by six days and seven hours, and that the month of December of 1833 was very wet, due to this large difference in time.

In the next table, PFo indicates that the time of perigee occurred earlier than the time of full moon by three days and nine hours in the first case, December 1847 being above the average in wetness.

In the third table, PFu denotes that the time of the full

moon was in advance, or occurred earlier than the time of perigee, and that in the first case the small difference of five hours was the cause of very dry weather, as in the above instances, and others given in tabular form for convenience, as follows :

		Days. Hours.		
1833.	PNo	6·7	W_5,	Dec.
1842.	,,	4·0	$W_{5,9}$	Nov.
1857.	,,	3·11	W_2,	Aug.
1866.	,,	4·9	W_1,	Aug.
1877.	,,	3·6	W_3,	Nov.
1886.	,,	4·12	W_3,	Nov.
1880.	,,	3·17	W_2,	Feb.
1889.	,,	5·7	W_2,	Feb.
1847.	PFo	3·9	W_1,	Dec.
1857.	,,	4·16	W_2,	Jan.
1859.	,,	5·11	W_2,	April
1869.	,,	3·16	W_4,	May
1860.	,,	5·13	W_6,	June
1869.	,,	3·16	W_4,	May
1861.	,,	5·15	W_1,	July
1871.	,,	7·22	W_6,	Sept.
1866.	,,	7·0	W_5,	Jan.
1875.	,,	4·7	W_3,	Jan.
1833.	PFu	0·5	D_4,	Jan.
1834.	,,	0·16	D_5,	Feb.
1835.	,,	0·15	D_2,	April
1836.	,,	0·15	D_3,	May
1837.	,,	0·17	D_2,	July
1838.	,,	0·16	D_1,	Sept.
1839.	,,	0·15	D_2,	Oct.
1840.	,,	0·12	D_5,	Dec.
1842.	,,	0·9	D_3,	Jan.
1843.	,,	0·6	D_4,	May
1844.	,,	0·4	D_6,	May
1845.	,,	0·6	D_2,	June
1846.	,,	0·8	D_1,	July
1847.	,,	0·7	D_2,	Sept.
1848.	,,	0·5	D_3,	Nov.
1849.	,,	0·2	D_1,	Dec.

		Days. Hours.		
1866.	PFo	7·0	W_5,	Jan.
1876.	,,	4·16	W_5,	Mar.
1869.	,,	3·16	W_4,	May
1878.	,,	5·0	W_7,	June
1869.	,,	3·16	W_4,	May
1879.	,,	5·3	W_5,	Aug.
1871.	,,	7·22	W_6,	Sept.
1880.	,,	5·4	W_4,	Sept.
1878.	,,	5·0	W_3,	June
1888.	,,	3·10	W_7,	July
1879.	,,	5·3	W_5,	Aug.
1888.	,,	3·10	W_7,	July
1875.	PFo	4·7	W_3,	Jan.
1876.	,,	4·16	W_5,	Mar.
1877.	,,	4·22	W_3,	April
1878.	,,	5·0	W_7,	June
1879.	,,	5·3	W_5,	Aug.
1880.	,,	5·4	W_4,	Sept.
1873.	PNo	0·13	D_1,	Feb.
1874.	,,	0·15	D_5,	Mar.
1875.	,,	0·16	D_1,	June
1876.	,,	0·15	D,	July
1877.	,,	1·2	D_4,	Sept.
1878.	,,	0·16	D_1,	Oct.
1879.	,,	0·18	D_3,	Dec.
1882.	,,	0·0	D_2,	Feb.
1883.	,,	...	D,	April
1884.	,,	0·3	D_3,	May
1885.	,,	0·3	D_1,	July
1886.	,,	0·4	D_4,	Aug.
1887.	,,	0·4	D_4,	Oct
1888.	,,	0·6	D_4,	Dec.

In the accompanying table the first line, marked (a), gives the interval of time in days and hours for each month of the year 1859, between the time of the moon's perigee and the time of new or full moon, F denoting full and N new, and u shows that the time of perigee is under, and o that it is over, the time of the new or full moon. The second line, marked (b), gives the same particulars for the year 1879; and the

third line, marked (c), shows that the intervals from November to January, backwards, for 1859, correspond month by month with those of 1879.

(a) 1859	Jan. 0·7Fu	Feb. 1·8Fu	Mar. 2·16Fu	Apl. 5·11Fu	May 4·3No	June 1·2No	July 0·9Nu	Aug. 0·19Nu	Sep. 1·20Nu	Oct. 3·12Nu	Nov. 6·6Fo	Dec. 2·23Fo
(b) 1879	6·5Fo	2·23Fo	1·12Fo	0·12Fo	0·9Fu	1·8Fu	2·15Nu	4·10No	2·8No	1·2No	0·4No	0·18Nu
(c) 1859	Nov. 6·6Fo	Oct. 3·12Nu	Sep. 1·20Nu	Aug. 0·19Nu	July 0·9Nu	June 1·2No	May 4·3No	Apl. 5·11Fu	Mar. 2·16Fu	Feb. 1·8Fu	Jan. 0·7Fu	Dec. 2·23Fo
(d) 1859	Jan. 4D	Feb. 2D	Mar. 2D	Apl. 2W	May 2W	June 2W	July 2W	Aug. 1W	Sep. 4W	Oct. 1D	Nov. 3W	Dec. 2W
(e) 1879	3W	5W.	2D	3W	5W	5W	5W	5W	3W	5D	4D	3D
(f) 1859	Dec. 2W	Nov. 3W	Oct. 1D	Sep. 4W	Aug. 1W	July 2W	June 2W	May 2W	Apl. 2W	Mar. 2D	Feb. 2D	Jan. 4D

In the table, D denotes drought and W wet, the numbers giving the degrees of dryness or wetness. The lines (d) and (e) give the degrees of drought and wet below and above the average rainfall for each month, and (f) shows that the drought and wet for 1859, back from December to January, corresponds month by month with that of 1879 from January to December. This case shows remarkable connexion between rainfall and the moon's apses, there being an exact and inverse correlation. The position of the moon in the node cycle, 27° to 28°, in 1859, compared with 25° to 26° in 1879, accounts for the smaller total rainfall of the former relative to the latter year.

With regard to the hour of the day when the new and full moon occur during 1859 and 1879 there is a peculiar inversion, but, grouping together the hours eleven, twelve, one, and two, when the greatest effects would be produced in London, with the corresponding and opposite times twenty-three, twenty-four, thirteen, and fourteen astronomical, and also the hours five, six, and seven, when the least effect is produced, with the intermediate hours three and four and eight, nine and ten, we have a very close, if not identical, relationship established between these years with regard to the hours of the day at which the changes of phase take place.

The inverse identity of rainfall in the years 1859 and 1879 appears to be the effect of the inverse relationship of the apses, due to the great coincidence in the time or tide cycle, and also to the close similarity in the relative positions in the node cycle.

FINIS.

INDEX

A A

B

C

Discoverer of the law enunciated in this work ; author of the predictions contained herein, and delineator of all the diagrams.

Born in Co. Down, Ulster, he arrived in London in early manhood, devoted himself to arduous and comprehensive studies in science and art, with special attention to astronomy, actively and unweariedly busied himself in the educational and intellectual needs of South London ; author of works on agriculture and surveying ; regular contributor to leading agricultural newspapers ; in the early Eighties set himself to discover the laws controlling the phenomena of weather causation, —after ten years secured a measure of success, continued, undauntedly, his investigations, and, in 1897, achieved a success in prediction unexampled in connexion with research into any science of so recondite a character as that of the movements of the heavenly bodies and the influence they exert one upon another ; still continuing his researches, in spite of misunderstanding and neglect, he has produced the scientific, well-ordered, and, seemingly, complete and satisfactory record of the causation of all terrestrial phenomena whereof the pages of this work are full. One of the most baffling and obscure of the

F.

G.